PATENT

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Application of: **MICHAEL T. DOBBERTIN, HENRY P. MITCHELL Jr.** Docket No.: 2000009

Serial No.: 09/688,001 Art Unit: 3651

Filed: October 14, 2000 Examiner: H. Grant Skaggs

For: **PULSED AIRKNIFE CONTROL FOR A VACUUM CORRUGATED FEED SUPPLY**

Assistant Commissioner of Patents & Trademarks
Washington, D.C. 20231

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BRIEF FOR APPELLANT

Sir:

This brief is filed in support of the Notice of Appeal filed on August 9, 2002. This brief is in support of an appeal from the final action of the Primary Examiner mailed February 15, 2002, and the subsequent Advisory Action mailed June 27, 2002.

I. THE REAL PARTY IN INTEREST

The real parties in interest are Heidelberg Digital, L.L.C., assignee of this application, and Heidelberger Druckmaschinen AG.

II. RELATED APPEALS AND INTERFERENCES

Appellant believes there are no related interferences or appeals that will have any bearing on this appeal.

III. STATUS OF THE CLAIMS

Claims 1-5 are pending in the application; claims 1-5 have been rejected. Appeal is taken on the rejected claims.

IV. STATUS OF THE AMENDMENTS

There have been no amendments made to claims 1-5. The appealed claims are included in Appendix A of this brief.

V. SUMMARY OF THE INVENTION AND ITS ILLUSTRATIVE EMBODIMENT

The invention is pulsed airknife control for a vacuum corrugated feed supply. A method of operating a vacuum corrugated belt feeder with positive air pressure separator during a feed cycle wherein the vacuum and the positive pressure air are controlled by a vacuum valve and a positive air pressure valve respectively, wherein the paper is taken away by a belt which is activated when a feed clutch is energized, comprising actuating the vacuum at the start of the feed cycle and de-actuating the vacuum when the feed clutch is de-energized, and pulsing the positive air pressure separator by actuating and de-actuating the positive air pressure separator during the feed cycle.

Referring to Figures 2-5, a sheet feed head assembly **30** is located in association with the hopper **12** so as to extend over a portion of the platform **14** in spaced relation to a sheet stack **15** supported thereon. The sheet feed head assembly **30** includes a ported plenum **32** connected to a vacuum source **31** through a vacuum valve **38**, and an airknife **40** connected to a positive pressure air source **41** through a positive pressure valve **60**. A positive pressure airjet from the airknife **40** levitates the top sheets in the supported sheet stack **15**. Vacuum at the plenum **32** is effective through the plenum ports **33** to cause the topmost levitated sheet from the stack to thereafter be

acquired at the plenum **32** for separation from the sheet stack **15**. Additional positive air pressure jets from the airknife **40** assure separation of subsequent sheets from the acquired topmost sheet (pg 4 lines 21-31).

A vacuum valve **38** (see Fig 5) is used to control the operation of the vacuum and to limit the vacuum level (pg 5 lines 1-2). When the vacuum is said to be "actuated", this means that the vacuum valve **38** is open. When the vacuum is said to be "de-actuated" this means that the vacuum valve **38** is closed (pg 5 lines 12-14).

The belts **36** are selectively driven by energizing a feed clutch (not shown), in a direction to remove the acquired sheet from the area above the sheet stack **15** and transport the sheet in the feed direction along a travel path to a downstream transport, such as a driven feed nip roller pair **50** (pg 5 lines 15-18). Accordingly when the clutch **56** is engaged, the belts **36** will be driven so as to feed an acquired sheet such that the acquired sheet is transported from the sheet stack **15** and is thereafter available for any further processing, such as receiving a reproduction from a copier or printer (pg 5 lines 23-26).

The airknife **40** comprises a first air jet arrangement **42** and a second air jet arrangement **44**. The first air jet arrangement incorporates a single nozzle **43** in fluid communication with a source of positive pressure air **41** (pg 5 lines 27-29). The nozzle **43** directs a positive pressure air stream at the sheet stack, in the center of the lead edge, to fluff the top sheets in the stack to bring the topmost sheet into association with the sheet feed head assembly **30** where it can be acquired by vacuum, at the plenum **32** (pg 6 lines 1-5). The second air jet arrangement **44** incorporates a plurality of nozzles **46** fluid communication with the source of positive pressure air **41**. The nozzles **46** are aimed slightly downstream of the aimpoint for the first air jet nozzle **43**. The purpose of the second air jet arrangement **44** is to separate any sheets adhering to the topmost sheet acquired by the sheet feed head assembly **30** (pg 6 lines 6-10).

A positive pressure air valve **60** is used to control the flow of positive pressure air through the airknife **40**. When the positive air pressure separator **40** is actuated, this means the positive air pressure valve **60** is open. When the positive air pressure

separator **40** is de-actuated, this means the positive air pressure valve **60** is closed (pg 6 lines 11-15).

Common practice for operation of a vacuum corrugated belt feeder with positive air pressure separator during a feed cycle, is to actuate the vacuum valve **38** and the positive air pressure separator **40** at the start of the feed cycle and de-actuate the vacuum valve **38** when the feed clutch is de-energized, but leave the positive air pressure separator **40** actuated throughout the feed cycle (pg 6 lines 21-25).

According to an aspect of the invention, this method is improved upon by pulsing the positive air pressure separator **40** by actuating and de-actuating the positive air pressure separator **40** during the feed cycle (pg 6 lines 26-28).

In a preferred embodiment of the invention, the positive air pressure separator **40** is actuated when the vacuum is actuated, and de-actuated before the feed clutch is energized (pg 6 lines 29-31). In a further preferred embodiment, the positive air pressure separator **40** is actuated when the vacuum is actuated, and is de-actuated approximately 50 milliseconds before the feed clutch is energized (pg 7 lines 3-5).

According to an aspect of the invention, a method of operating a vacuum corrugated belt feeder with positive air pressure separator during a feed cycle comprises opening the vacuum valve **38** and the positive pressure air valve **60,** then closing the positive pressure air valve **60,** next energizing the feed clutch on the belt feeder, then de-energizing the feed clutch, and finally closing the vacuum valve **38** (pg 7 lines 24-28).

VI. ISSUES ON APPEAL

A) The unobviousness of claim 5 over Yoshida et al in view of Jantsch et al.

B) The unobviousness of claims 1-4 over Yoshida et al in view of Jantsch et al as applied to claim 5, and further in view of Watkiss.

C) The unobviousness of claims 2-3 over Yoshida et al in view of Jantsch et al as applied to claim 5, and further in view of Watkiss, and further considering "mere choice or expedience".

D) The unobviousness of claims 1-4 over Yoshida et al in view of Jantsch et al as applied to claim 5, and further in view of Watkiss and further considering "mere choice or expedience".

VII. THE ART RELIED ON BY THE EXAMINER

Yoshida et al	USP 5,478,066	12/1995
Jantsch et al	USP 5,344,133	9/1994
Watkiss	USP 6,120,016	9/2000

VIII. GROUPING OF THE CLAIMS

Claims 1-4 have been rejected under 35 U.S.C. §103 over Yoshida et al in view of Jantsch et al as applied to claim 5, and further in view of Watkiss. As described in the arguments below, Appellant considers each of these claims to be separately patentable. Appellant requests that the claims be considered individually.

IX. APELLANT'S ARGUMENTS

A) **THE UNOBVIOUSNESS OF CLAIM 5 OVER YOSHIDA ET AL IN VIEW OF JANTSCH ET AL.**

Claim 5 stands rejected under 35 U.S.C. §103 over Yoshida et al in view of Jantsch et al. The Examiner's position is summarized below.

Yoshida et al shows in Fig. 34 the timed operation of a vacuum belt feeder which includes first opening a vacuum valve 13 (at c) and a positive pressure air valve 22 (at a), closing the pressure air valve (at b), driving the belt feeder (14), closing the vacuum (at d), and then turning off the drive to the belt. Further, in the embodiments of Figs. 25-28 of Yoshida et al (to which the

time chart of Figure 34 could apply) it is shown that the pressure air valve 22 does move between the open position a and the closed position b. Merely having the vacuum of Yoshida et al run until after the feed belt is de-energized would require mere choice or expedience since it would appear that the apparatus run equally well with the vacuum turned off after the de-energizing of the belt (14). Further to have the feed belt activated and deactivated by way of a feed clutch would require the mere choice of a known means of controlling the movement of the belt as made obvious by Jantsch et al. Note 56 and column 5 lines 30-46 of Jantsch et al.

Appellant pointed out that Figure 34 in Yoshida et al does not show a positive pressure air valve either opening OR closing, what it does show is the position of the positive pressure air valve switching from position a to position b. Therefore, since the positive pressure air valve of Yoshida et al in Figure 34 is never closed during the feed cycle, and since "closing said positive pressure air valve" is a limitation of Appellant's claim 5 (pg 8 line 28), claim 5 is not obvious over Yoshida et al in view of Jantsch et al. The Examiners response to this was that there were embodiments in Yoshida et al of Figs. 25-28 wherein it is shown that the pressure air valve 22 does move between the open position a and the closed position b, and that the time chart of Figure 34 could apply to these embodiments. However, the timing chart of Figure 34 could not possibly apply to the embodiments of Figs. 25-28, because applying the embodiments of Figures 25-28 to the timing chart of Fig 34 does not produce the "blow amount of nozzle 19" presented in Figure 34. For example, in Figs. 25-38, when the pressure air valve 22 is in the closed position b there would be no airflow through nozzle 19. Figure 34 clearly shows that when valve 22 is in position b that there is non-zero airflow Q1 in nozzle 19; and further that the airflow through nozzle 19 is greater when the valve 22 is in position b (closed position for Figure 25-28) than when it is position a (open position for Figure 25-28). This clearly contradicts the Examiner's position that the timing chart of Figure 34 could apply to embodiments 25-28.

The Examiner also states that "merely having the vacuum of Yoshida et al run until after the feed belt is de-energized would require mere choice or expedience since it would appear that the apparatus run equally well with the vacuum turned off after the de-energizing of the belt (14)". Appellants have requested a factual support for this conclusory statement, but the Examiner has not provided any such factual basis. This limitation has not been found in the relied upon art, thus the only basis for rejection is the Examiner's opinion. Appellants argue that this is a mere conclusion, unsupported by facts.

Thus, Figure 34 of Yoshida et al is not applicable to Appellant's claim 5 and Figure 34 of Yoshida et al could not possibly apply to the embodiments of Figures 25-28 of Yoshida et al. Further, the factual record does not support the conclusion that "merely having the vacuum of Yoshida et al run until after the feed belt is de-energized would require mere choice or expedience". For these reasons, and because the Examiner is relying on Jantsch et al only for the use of a feed clutch, claim 5 is not obvious under 35 U.S.C. §103 over Yoshida et al in view of Jantsch et al.

Appellant requests reversal of the Examiner regarding rejection of claim 5.

B) **THE UNOBVIOUSNESS OF CLAIMS 1-4 OVER YOSHIDA ET AL IN VIEW OF JANTSCH ET AL AS APPLIED TO CLAIM 5, AND FURTHER IN VIEW OF WATKISS.**

Claims 1-4 stand rejected under 35 U.S.C. §103 over Yoshida et al in view of Jantsch et al as applied to claim 5 above, and further in view of Watkiss. The Examiner's position is summarized below.

It would be obvious in order to aid in separation of the sheets from the stack to have the positive air pressure from valve 22 of Yoshida et al delivered in pulses as made obvious by Watkiss. Note air blasts from nozzles 72 and column 5 lines 6-30 of Watkiss.

As discussed above, the Examiner has interpreted Yoshida et al in a way which is not consistent with its plain meaning.

Further, as discussed above, Yoshida has an embodiment wherein the position of the positive pressure air valve switches from position a to position b, but the positive pressure air remains flowing (Fig 34), and an embodiment wherein the positive pressure air valve 22 moves between an open position a and a closed position b (Figure 25-28). The Examiner does not specify which of these embodiments he is referring to in his combination of references.

In the embodiment of Yoshida et al of Figure 34, where the positive pressure air valve switches from position a to position b, but the positive pressure air remains flowing, there is no obvious way of combining Watkiss. Would you pulse the air while the valve was in position a? Would you pulse the air when the valve was in position b? Would you pulse from position a to position b? Pulsing is not appropriate for this embodiment, as a detailed timing chart (Figure 34) for desired airflows at various times throughout the feed cycle is already presented.

In the embodiment of Yoshida et al wherein the positive pressure air valve 22 moves between an open position a and a closed position b (Figure 25-28), the valve 22 is switched to position a, then the vacuum valve is opened, then valve 22 is switched to position b "to stop the injection of the air" "At the same time" as the convey belt is actuated (see column 18 lines 1-8 and lines 37-42). In contrast, Watkiss has the positive air being pulsed "in synchronism with the operation of the vacuum device and the belt movement" (column 6 lines 38-41). Thus in Yoshida et al, the positive air is stopped at the same time the belt is actuated, and in Watkiss the positive air is turned ON at the same time the belt is actuated. Thus they directly conflict with each other, so not only is there no motivation to combine Yoshida et al and Watkiss, but it could not be done.

Claim 2 has the limitation that "said positive air pressure is de-actuated before the feed clutch is energized" (pg 8 lines 12-14) and thus is separately patentable. As discussed above, in Watkiss the positive pressure is turned ON when the belt is actuated, which directly opposes claim 2.

Claim 3 has the limitation that "when the feed rate is 110 pages per minute, wherein said positive air pressure separator is actuated when said vacuum is actuated, and said positive air pressure is de-actuated approximately 50 milliseconds before the feed clutch is energized" (pg 8 lines 15-18) and thus is separately patentable. As

discussed above, in Watkiss the positive pressure is turned ON when the belt is actuated, which directly opposes claim 3.

Claim 4 has the limitation "when the feed rate is 110 pages per minute, wherein said positive air pressure valve is closed approximately 50 milliseconds before the feed clutch being energized" (pg 8 lines 19-21) and thus is separately patentable. As discussed above, in Watkiss the positive pressure is turned ON when the belt is actuated, which directly opposes claim 4.

For these reasons, and because the Examiner is relying on Jantsch et al only for the use of a feed clutch, claims 1-4 are not obvious under 35 U.S.C. §103 over Yoshida et al in view of Jantsch et al as applied to claim 5 above, and further in view of Watkiss.

Appellant requests reversal of the Examiner regarding rejection of claims 1-4.

C) **THE UNOBVIOUSNESS OF CLAIMS 2-3 OVER YOSHIDA ET AL IN VIEW OF JANTSCH ET AL AS APPLIED TO CLAIM 5, AND FURTHER IN VIEW OF WATKISS, AND FURTHER CONSIDERING "MERE CHOICE OR EXPEDIENCE".**

Claims 2-3 stand rejected under 35 U.S.C. §103 over Yoshida et al in view of Jantsch et al as applied to claim 5 above, and further in view of Watkiss, and further considering "mere choice or expedience". The Examiner's position is summarized below.

In regard to claims 2-3 merely having the air pressure separator (at a of 22 of Fig. 34) of Yoshida et al actuated at the same time as the vacuum is actuated (at 13 c of Fig 34) would require mere choice or expedience since the apparatus of Yoshida et al could work equally well with this type of timed operation. The Examiner has made a factual observation of the modified Yoshida et al apparatus and the burden is now on Appellant to refute such observations.

Appellant respectfully submits that the Examiner's observation has not been established as fact, and there is no factual support in the record for such an observation. Appellants have twice requested a factual support for this

conclusory statement, but the Examiner has not provided any such factual basis. This limitation has not been found in the relied upon art, thus the only basis for rejection is the Examiner's opinion. Appellants argue that this is a mere conclusion, unsupported by facts.

Further, with regard to claim 2, the Examiner speaks to the limitation of having the positive air pressure separator actuated when the vacuum is actuated, however, the Examiner does not address the limitation of the "positive air pressure is de-actuated before the feed clutch is energized." If the Examiner is relying on the timing chart Figure 34 of Yoshida et al for this limitation, Appellant respectfully submits that for the reasons stated in section A above, Figure 34 of Yoshida et al is not applicable.

For these reasons, and because the Examiner is relying on Jantsch et al only for the use of a feed clutch, claims 2-3 are not obvious under 35 U.S.C. §103 over Yoshida et al in view of Jantsch et al as applied to claim 5, and further in view of Watkiss, and further considering "mere choice or expedience".

Appellant requests reversal of the Examiner regarding rejection of claims 2-3.

D) **THE UNOBVIOUSNESS OF CLAIMS 3-4 OVER YOSHIDA ET AL IN VIEW OF JANTSCH ET AL AS APPLIED TO CLAIM 5, AND FURTHER IN VIEW OF WATKISS, AND FURTHER CONSIDERING "MERE CHOICE OR EXPEDIENCE".**

Claims 3-4 stand rejected under 35 U.S.C. §103 over Yoshida et al in view of Jantsch et al as applied to claim 5 above, and further in view of Watkiss, and further considering "mere choice or expedience". The Examiner's position is summarized below.

To have the time between the closing of the valve 22 (at b) and the activation of the feed belt 14 of Yoshida et al to be approximately 50 milliseconds would require mere choice of expedience based on the timing of the feed rate of the sheets being fed. Examiner has made a factual observation of the modified Yoshida et al apparatus and the burden is on Appellant to refute such observations.

Appellant respectfully submits that the Examiner's observation has not been established as fact, and there is no factual support in the record for such an observation. Appellants have twice requested a factual support for this conclusory statement, but the Examiner has not provided any such factual basis. This limitation has not been found in the relied upon art, thus the only basis for rejection is the Examiner's opinion. Appellants argue that this is a mere conclusion, unsupported by facts.

On the contrary, claims 3-4 contain the limitation the positive air pressure is de-actuated approximately 50 milliseconds before the feed clutch is energized. Neither Yoshida et al nor Watkiss has the positive air pressure de-actuated before the feed clutch is energized. In Yoshida et al, the positive pressure air valve 22 moves between an open position a and a closed position b (Figure 25-28), the valve 22 is switched to position a to open the vacuum valve, then valve 22 is switched to position b "to stop the injection of the air" "At the same time" as the convey belt is actuated (see column 18 lines 1-8 and lines 37-42). Watkiss has the positive air being pulsed "in synchronism with the operation of the vacuum device and the belt movement" (column 6 lines 38-41). Therefore, one has the positive pressure actuated at the same time the feed clutch is energized, and one has the positive pressure de-actuated at the same time the feed clutch is energized.

For these reasons, and because the Examiner is relying on Jantsch et al only for the use of a feed clutch, claims 3-4 are not obvious under 35 U.S.C. §103 over Yoshida et al in view of Jantsch et al as applied to claim 5, and further in view of Watkiss, and further considering "mere choice or expedience".

Appellant requests reversal of the Examiner regarding rejection of claims 3-4.

IX. SUMMARY

Appellant's claimed pulsed airknife control for a vacuum corrugated feed supply (claims 1-5) is distinct and patentably defined over the cited references as applied by the Examiner. Appellant requests reversal of the final rejection in its entirety.

Respectfully submitted,

Kathleen K. Bowen

Kathleen K. Bowen
Attorney for Appellant
Reg. No. 42,352
(330)945-6931

Date: 10/9/2002

TABLE OF CONTENTS FOR APPENDICIES

APPENDIX 1

PULSED AIRKNIFE CONTROL FOR A VACUUM CORRUGATED FEED SUPPLY

BACKGROUND

The present invention is in the field of printers and copiers. More specifically this invention relates to a receiver sheet supply and feed apparatus, including a vacuum corrugated feeder, and a positive air pressure separator on such printers and copiers. This invention is useful for the apparatus described by the US Patent # 5,344,133 "Vacuum belt feeder having a positive air pressure separator and method of using a vacuum belt feeder " by Jantsch et al, which patent is hereby incorporated by reference in its entirety. The incorporated patent refers to a vacuum, a first positive air supply, and a second positive air supply. The first and second positive air supplies are used simultaneously and will herein be referred to collectively as the airknife.

In typical reproduction apparatus such as copiers or printers, information is reproduced on individual cut sheets of receiver material such as plain bond paper or transparencies. Such receiver sheets are stored in a stack and fed individually when copies are to be produced. The sheet feeder for the reproduction apparatus must be able to handle a wide range of sheet types and sizes reliably and without damage. Sheets must be fed individually, without misfeeds or multi-feeds.

In the vacuum corrugated belt feeder disclosed in the above patent, both the vacuum and the positive air pressure are controlled by valves. During the feed cycle, the positive air pressure valve is continuously open. The vacuum valve is opened to acquire the top sheet off the stack. After approximately 220 milliseconds (for a 110 pages per minute (ppm) feed rate), the clutch is actuated, which drives the feed belts to advance the sheet into the constantly rotating take away rollers. At a time after the lead edge of the sheet has reached the take away rollers, prior to the trail edge of the sheet reaching the edge of the ports in the vacuum plenum, the vacuum and the clutch are turned off.

The airknife airflow and velocity during the acquisition phase must be great enough to fluff the stack and pre-separate the top sheet. During the transport phase, the flow from the airknife must be high enough to create the air bearing between the sheet being fed, and the rest of the stack. However, flow that is too high during the transport phase has several undesirable effects. For example, if the flow is too high there is an increased tendency for the sheets below the top sheet to be blown back away from the lead edge. This is especially troublesome for sheets that do not have a continuous trail edge. Also, the air can deflect the lead edge of sheets with low stiffness, especially if the paper curl is down (lead edge away from the feed belts), which can lead to paper damage or jamming. The flow must not be so great as to levitate any sheets below the sheet being fed above the mechanical gate fingers along the lead edge of the paper drawer, or high enough to cause the second sheet to contact the top sheet when it is being transported off the stack. Also, if the flow is too great, it can cause the trail edge of the sheet being fed to flutter violently, which can in turn contact the sheet below it, tending to drive it forward also.

Typically, the minimum airflow of the airknife is dictated by the acquisition and separation needs and the maximum airflow of the airknife is limited by the transport phase. A method of operation is desired which will optimize the usefulness of the airknife during the acquisition and separation phase, while minimizing the detriments of the airknife during the transport phase.

SUMMARY OF THE INVENTION

A method of operating a vacuum corrugated belt feeder with positive air pressure separator during a feed cycle wherein the vacuum and the positive pressure air are controlled by a vacuum valve and a positive air pressure valve respectively, wherein the paper is taken away by a belt which is activated when a feed clutch is energized, comprising actuating the vacuum at the start of the feed cycle and de-actuating the vacuum when the feed clutch is de-energized, and pulsing the positive air pressure separator by actuating and de-actuating the positive air pressure separator during the feed cycle.

BRIEF DESCRIPTION OF THE DRAWINGS

FIGURE 1 is a side view of a receiver sheet supply and feeding apparatus.

FIGURE 2 is a top plan view of a receiver sheet supply and feeding apparatus of Fig 1 with portions removed or broken away to facilitate viewing

FIGURE 3 is a side view of a cross-section of a receiver sheet supply and feeding apparatus taken along lines 3—3 of Fig. 2.

FIGURE 4 is a side cross-sectional view of a portion of a receiver sheet supply and feeding apparatus,

FIGURE 5 is an end view of a portion of the receiver sheet supply and feeding apparatus, taken along the lines 5—5 of Fig. 3.

FIGURE 6 is an end view of a portion of the receiver sheet supply and feeding apparatus, taken along the lines 6—6 of Fig. 3.

DETAILED DESCRIPTION

The US Patent # 5,344,133 "Vacuum belt feeder having a positive air pressure separator and method of using a vacuum belt feeder " by Jantsch et al, describes an apparatus which uses both vacuum and positive pressure air pressure to separate and acquire the top sheet of a supply stack. In this invention, both the vacuum line and the positive air pressure line are routed through valves, which valves are used to control the flow of vacuum and positive air. During typical operation of a printer/copier which uses the apparatus described in US Patent # 5,344,133, both the vacuum valve and the positive air pressure valve are open during the feed cycle, and closed when the printer/copier is not feeding from that particular supply.

Following is a detailed description of the drawings which show the vacuum belt feeder with positive air pressure separator as described in US Patent # 5,344,133. Although this system is described in detail, the present invention is not limited to use in this particular system. Any printer/copier which uses a combination of vacuum and positive air pressure to lift and separate the top sheets from a feed stack may make use of this invention.

The detailed description is written to a top feed vacuum corrugated feed device, but the present invention is also useful for a bottom feed vacuum belt feed device. In the case of a bottom feed device, instead of separating the top sheet, the vacuum with the airknife would be separating the bottom sheet.

Various aspects of the invention are presented in Figures 1-6 which are not drawn to scale and in which like components are numbered alike. Referring now to Figures 1-2, a receiver sheet supply and feeding apparatus are shown. The receiver sheet supply and feeding apparatus designated generally by the numeral **10**, includes an open hopper **12** and an elevating platform **14** for supporting a stack of sheets. A sheet stack **15** supported on the platform **14** contains individual sheets suitable for serving as receiver sheets for having reproductions formed thereon in a copier or printer device.

The sheet stack-supporting platform **14** is supported within the hopper **12** for substantially vertical elevational movement by a lifting mechanism. The lifting mechanism serves to raise the platform **14** to an elevation for maintaining the topmost sheet in the stack at a predetermined level during operation. Maintaining the topmost sheet at the predetermined level is accomplished by a sheet detection switch **80** (see Fig 5), or multiple switches, which controls the operation of a motor for actuating the lifting mechanism to raise the platform until a switch or switches is activated.

A sheet feed head assembly **30** is located in association with the hopper **12** so as to extend over a portion of the platform **14** in spaced relation to a sheet stack **15** supported thereon. The sheet feed head assembly **30** includes a ported plenum **32** connected to a vacuum source **31** through a vacuum valve **38**, and an airknife **40** connected to a positive pressure air source **41** through a positive pressure valve **60**. A positive pressure airjet from the airknife **40** levitates the top sheets in the supported sheet stack **15**. Vacuum at the plenum **32** is effective through the plenum ports **33** to cause the topmost levitated sheet from the stack to thereafter be acquired at the plenum **32** for separation from the sheet stack **15**. Additional positive air pressure jets from the airknife **40** assure separation of subsequent sheets from the acquired topmost sheet.

A vacuum valve **38** (see Fig 5) is used to control the operation of the vacuum and to limit the vacuum level. Thus during a feed cycle, the valve will be open so as to levitate the top sheet in the stack. In a preferred method of operation, the opening and closing of the vacuum valve is timing based, however, valve operation may also be controlled by other methods, such as a pressure or a mechanically activated switch. For example, a switch may be attached to the plenum **32** to detect when a sheet has been acquired. A signal provided by the switch on detection of sheet acquisition may be utilized to control operation of various components of the sheet feed head assembly **30**, such as timing of activations or setting of air flow levels, to optimize operation for a particular type (size) of sheet to be fed from the sheet supply and feeding mechanism **10**. When the vacuum is said to be "actuated", this means that the vacuum valve **38** is open. When the vacuum is said to be "de-actuated" this means that the vacuum valve **38** is closed.

The belts **36** are selectively driven by energizing a feed clutch (not shown), in a direction to remove the acquired sheet from the area above the sheet stack **15** and transport the sheet in the feed direction along a travel path to a downstream transport, such as a driven feed nip roller pair **50.** The nip roller pair **50** is driven by a motor. A gear **52** is rotatably mounted on a shaft (not shown) supporting one roller of the nip roller pair **50**. A clutch **56** is selectively activated to couple the gear **52** to the shaft **54** for rotation with the shaft. An intermediate gear **58** is in mesh with the gear **52** and a gear (not shown) coupled to one of the belt rollers **39**. Accordingly when the clutch **56** is engaged, the belts **36** will be driven so as to feed an acquired sheet such that the acquired sheet is transported from the sheet stack **15** and is thereafter available for any further processing, such as receiving a reproduction from a copier or printer.

The airknife **40** comprises a first air jet arrangement **42** and a second air jet arrangement **44**. The first air jet arrangement incorporates a single nozzle **43** in fluid communication with a source of positive pressure air **41**, for example a range of 4-10 inwg in certain embodiments. The chambers which are part of the first air jet arrangement **42** and the second air jet arrangement **44** may be

separate chambers, or may be combined into one larger chamber. The nozzle **43** directs a positive pressure air stream at the sheet stack, in the center of the lead edge, to fluff the top sheets in the stack to bring the topmost sheet into association with the sheet feed head assembly **30** where it can be acquired by vacuum, at the plenum **32**.

The second air jet arrangement **44** incorporates a plurality of nozzles **46** fluid communication with the source of positive pressure air **41**. The nozzles **46** are aimed slightly downstream of the aimpoint for the first air jet nozzle **43**. The purpose of the second air jet arrangement **44** is to separate any sheets adhering to the topmost sheet acquired by the sheet feed head assembly **30**.

A positive pressure air valve **60** is used to control the flow of positive pressure air through the airknife **40**. When the positive air pressure separator **40** is actuated, this means the positive air pressure valve **60** is open. When the positive air pressure separator **40** is de-actuated, this means the positive air pressure valve **60** is closed. However, when the positive air pressure valve **60** is closed, that does not necessarily mean that there is no positive pressure airflow. In a preferred design, the positive air pressure valve **60** allows some airflow even when closed (does not close all the way). One commonly used valve design allows about one third of the airflow through an open valve to flow through when the valve is 'closed'.

Common practice for operation of a vacuum corrugated belt feeder with positive air pressure separator during a feed cycle, is to actuate the vacuum valve **38** and the positive air pressure separator **40** at the start of the feed cycle and de-actuated the vacuum valve **38** when the feed clutch is de-energized, but leave the positive air pressure separator **40** actuated throughout the feed cycle.

According to an aspect of the invention, this method is improved upon by pulsing the positive air pressure separator **40** by actuating and de-actuating the positive air pressure separator **40** during the feed cycle.

In a preferred embodiment of the invention, the positive air pressure separator **40** is actuated when the vacuum is actuated, and de-actuated before the feed clutch is energized. According to this aspect of the invention, the

positive air pressure separator is actuated during the acquisition phase, and de-actuated during the transport phase.

In a further preferred embodiment, the positive air pressure separator **40** is actuated when the vacuum is actuated, and is de-actuated approximately 50 milliseconds before the feed clutch is energized. This time may be optimized for different operating feed rates, for example it may need to be less for higher speed feeds. By pulsing the positive air pressure separator **40**, the high pressure achieved may be higher, and the low pressure (flow when the positive air pressure valve **60** is 'closed') may be lower. This means that during the acquisition phase, when the high pressure is needed to separate the sheets, higher pressure is available. During the transport phase, when higher pressure causes problems, the pressure is lower because the positive air pressure separator **40** is de-actuated. This allows the receiver sheet supply and feeding apparatus **10** to function better for heavier papers, due to the higher pressure during acquisition. It also allows the receiver sheet supply and feeding apparatus **10** to work better for lighter papers, due to the lower pressure during transport. Thus this invention opens the operating window of the receiver sheet supply and feeding apparatus **10.** This control may allow the high air level to increase as much as by a factor of two without significantly impacting feed performance on light paper.

Also, on copiers/printers with multiple sheet supplies, this invention enables a smaller blower to do the same job because the positive air pressure separator **40** is not actuated throughout the feed cycle.

According to an aspect of the invention, a method of operating a vacuum corrugated belt feeder with positive air pressure separator during a feed cycle comprises opening the vacuum valve **38** and the positive pressure air valve **60,** closing the positive pressure air valve **60,** energizing the feed clutch on the belt feeder, de-energizing the feed clutch, and closing the vacuum valve **38**.

What is claimed is:

1. In a method of operating a vacuum corrugated belt feeder with positive air pressure separator during a feed cycle wherein said vacuum and said positive pressure air are controlled by a vacuum valve and a positive air pressure valve respectively, wherein the paper is taken away by a belt which is activated when a feed clutch is energized, wherein the vacuum is actuated at the start of the feed cycle and de-actuated when the feed clutch is de-energized, the improvement comprising:

pulsing the positive air pressure separator by actuating and de-actuating said positive air pressure separator during the feed cycle.

2. The method of claim 1 wherein said positive air pressure separator is actuated when said vacuum is actuated, and said positive air pressure is de-actuated before the feed clutch is energized.

3. The method of claim 1 when the feed rate is 110 pages per minute, wherein said positive air pressure separator is actuated when said vacuum is actuated, and said positive air pressure is de-actuated approximately 50 milliseconds before the feed clutch is energized.

4. The method of claim 1 when the feed rate is 110 pages per minute, wherein said positive air pressure valve is closed approximately 50 milliseconds prior to the clutch being energized.

5. A method of operating a vacuum corrugated belt feeder with positive air pressure separator during a feed cycle wherein said vacuum and said positive pressure air are controlled by a vacuum valve and a positive air pressure valve respectively, wherein the paper is taken away by a belt which is activated when a feed clutch is energized, comprising:

opening said vacuum valve and said positive pressure air valve;

closing said positive pressure air valve;

energizing the feed clutch on the belt feeder;

de-energizing the feed clutch ; and,

closing said vacuum valve.

ABSTRACT

A method of operating a vacuum corrugated belt feeder with positive air pressure separator during a feed cycle wherein the vacuum and the positive pressure air are controlled by a vacuum valve and a positive air pressure valve respectively, wherein the paper is taken away by a belt which is activated when a feed clutch is energized, comprising actuating the vacuum at the start of the feed cycle and de-actuated the vacuum when the feed clutch is de-energized, and pulsing the positive air pressure separator by actuating and de-actuating the positive air pressure separator during the feed cycle.

APPENDIX 2

CERTIFICATE OF MAILING

I hereby certify that this correspondence is being deposited with the United States Postal Service as first class mail, with sufficient postage, in an envelope addressed to: ~~Assistant~~ Commissioner for Patents, Washington D.C. 20231, on

2/1/02
Date of Deposit

Kathleen Bowen
Name of Applicant, Assignee, or Registered Representative

Kathleen Bowen
Signature

2/1/02
Date of Signature

Attorney Docket No. 2000009

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Application of:

Michael T. Dobbertin and
Henry P. Mitchell, Jr.

Serial No. 09/688,001

Filing Date: October 14, 2000

For PULSED AIRKNIFE CONTROL FOR VACUUM CORRUGATED FEED SUPPLY

Examiner H. Grant Skaggs

Group Art Unit No. 3651

Assistant Commissioner for Patents
Washington, D.C. 20231

Dear Sir:

In response to the office action mailed on November 1, 2001:

Claim 5 stands rejected under 35 U.S.C. 103 (a) as being unpatentable over Yoshida et al in view of Jantsch et al. Claims 1-4 stand rejected under 35

U.S.C. 103 (a) as being unpatentable over Yoshida et al in view of Jantsch et al, and further in view of Watkiss. Applicants respectfully submit that for the following reasons, claim 5 is not obvious by Yoshida et al in view of Jantsch et al under 35 U.S.C. 103 (a) and claims 1-4 are not obvious by Yoshida et al in view of Jantsch et al and further in view of Watkiss under 35 U.S.C. 103 (a). Applicants respectfully request reconsideration and further examination of claims 1-5.

In his rejection of claim 5, the examiner states that "Yoshida et al shows in Fig. 34 the timed operation of a vacuum belt feeder which includes first opening a vacuum valve 13 (at c) and a positive pressure air valve 22 (at a), closing the pressure air valve (at b), driving the belt feeder (14), closing the vacuum (at d), and then turning off the drive belt." Applicant respectfully submits that this is in error. Figure 34 in Yoshida et al does not show a positive pressure air valve either opening OR closing, what it does show is the position of the positive pressure air valve switching from position a to position b. The applicants respectfully request the examiner specifically cite where in the reference the positive pressure air valve closes during normal operation. The examiner cites Jantsch et al solely for the choice of a feed clutch as a known means for controlling the movement of the belt. Therefore, since neither Figure 34 of Yoshida et al nor Jantsch et al discloses the positive air pressure valve closing, Claim 5 is not obvious by Yoshida et al in view of Jantsch et al under 35 U.S.C. 103 (a), and applicants respectfully submit that rejection of claim 5 on this basis is in error, and request that the rejection on this basis be withdrawn.

The examiner states that it would be obvious to have the positive air pressure from valve 22 of Yoshida et al delivered in pulses as made obvious in Watkiss. As discussed above, Yoshida et al does not disclose valve 22 closing at all, merely switching position from position a to position b. It would not be obvious to combine the pulses from Watkiss into Yoshida et al, since Yoshida et al counts on the constant flow of positive pressure air, only in different directions, to separate sheets from the stack. Applicants respectfully request examiner to

disclose the motivation to combine these references. Because there is no motivation to combine these references, in fact the function of Yoshida et al would seem to teach against it, applicant respectfully submits that claims 1-4 are not obvious by Yoshida et al in view of Jantsch et al and further in view of Watkiss under 35 U.S.C. 103 (a), and applicants respectfully request that examiner withdraw the rejection on this basis.

Examiner further states that with regard to claims 2-3, "merely having the air pressure separator (at a of 22 of Fig. 34) of Yoshida et al actuated at the same time as the vacuum is actuated (at 13 c of Fig 34) would require mere choice or expedience since the apparatus of Yoshida et al could work equally well with this type of timed operation". Applicants respectfully request the examiner provide a factual basis for the statement that having the air pressure separator of Yoshida et al actuated at the same time as the vacuum is actuated would require mere choice or expedience so applicants can adequately respond. In the absense of such, applicants respectfully submit that rejection of claims 2-3 on this basis is in error, and respectfully request rejection on this basis be withdrawn.

Examiner further states with regard to claims 3 and 4, that "to have the time between the closing of the valve 22 (at b) and the activation of the feed belt 14 of Yoshida et al to be approximately 50 milliseconds would require mere choice of expedience based on the timing of the feed rate of the sheets being fed". As discussed above, the valve 22 in Yoshida et al does NOT close, but merely switches position from a to b. Applicants respectfully request examiner to cite a factual basis for the statement that the time between the closing of the positive pressure air valve and the activation of the feed belt of 50 milliseconds is a "mere choice of expedience" so that applicants may adequately respond. In absence of this, applicants respectfully submit rejection of claims 3-4 on this basis is in error, and applicants respectfully request the rejection on this basis be withdrawn.

Applicants respectfully submit that claims 1-5 are allowable as written, and request that the rejections against them be withdrawn.

Respectfully submitted,

Kathleen K. Bowen, Esq.
Registration No. 42,352
Attorney for Applicants

APPENDIX 3

DETAILED ACTION

Claim Rejections - 35 USC § 103

1. The following is a quotation of 35 U.S.C. 103(a) which forms the basis for all obviousness rejections set forth in this Office action:

> (a) A patent may not be obtained though the invention is not identically disclosed or described as set forth in section 102 of this title, if the differences between the subject matter sought to be patented and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a person having ordinary skill in the art to which said subject matter pertains. Patentability shall not be negatived by the manner in which the invention was made.

2. Claim 5 is rejected under 35 U.S.C. 103(a) as being unpatentable over Yoshida et al in view of Jantsch et al.

Yoshida et al shows in Fig.34 the timed operation of a vacuum belt feeder which includes first opening a vacuum valve 13 (at c) and a positive pressure air valve 22 (at a), closing the pressure air valve (at b), driving the belt feeder (14), closing the vacuum (at d), and then turning off the drive to the belt. Yoshida et al does not teach that the vacuum can run after de-energizing the belt or that the belt can be energized and de-energized by way of a feed clutch. Merely having the vacuum of Yoshida et al run until after the feed belt is de-energized would require mere choice or expedience since it would appear that the apparatus run equally well with the vacuum turned off after the de-energizing of the belt (14). Further to have the feed belt activated and deactivated by way of a feed clutch would require the mere choice of a known means of controlling the movement of the belt as made obvious by Jantsch et al. Note 56 and column 5 lines 30-46 of Jantsch et al.

3. Claims 1-4 are rejected under 35 U.S.C. 103(a) as being unpatentable over Yoshida et al in view of Jantsch et al as applied to claim 5 above, and further in view of Watkiss.

It would be obvious in order to aid in the separation of the sheets from the stack to have the positive air pressure from valve 22 of Yoshida et al delivered in pulses as made obvious by Watkiss. Note air blast from nozzles 72 and column 5 lines 6-30 of Watkiss. In regard to claims 2-3 merely having the air pressure separator (at a of 22 of Fig. 34) of Yoshida et al actuated at the same time as the vacuum is actuated (at 13 c of Fig. 34) would require mere choice or expedience since the apparatus of Yoshida et al could work equally well with this type of timed operation. With regard to claims 3 and 4 to have the time between the closing of valve 22 (at b) and the activation of the feed belt 14 of Yoshida et al to be approximately 50 milliseconds would require mere choice or expedience based on the timing and feed rate of the sheets being feed.

Response to Arguments

4. Applicants' arguments filed February 1, 2002 have been fully considered but they are not persuasive.

Applicants argue that Yoshida et al does not teach that the time chart of Fig. 34 does not show that a positive pressure air valve either opening or closing but only shows position changing. However in the embodiments of Figs. 25-28 of Yoshida et al (to which the time chart of Fig. 34 could apply) it is shown that the pressure air valve 22 does move between the open position a and

the closed position b. With regard to claim 5 applicants argue that there is no motivation to combine Yoshida et al with Watkiss to provided air blast. However Watkiss in column 5 lines 21-23 clearly teaches that air blast aid in the separation of a top sheet. The motivation to combine the teaching of Watkiss with Yoshida et al is therefor clearly found in the references. Moreover, the examiner does not agree that the Yoshida et al apparatus counts on a constant flow of pressure air in different directions as Figs. 25-28 clearly show otherwise. With regard to the arguments concerning claims 2-3 and 3-4, the examiner as made a factual observation of the modified Yoshida et al apparatus and the burden is no on applicant to refute such observations.

Conclusion

5. **THIS ACTION IS MADE FINAL.** Applicant is reminded of the extension of time policy as set forth in 37 CFR 1.136(a).

A shortened statutory period for reply to this final action is set to expire THREE MONTHS from the mailing date of this action. In the event a first reply is filed within TWO MONTHS of the mailing date of this final action and the advisory action is not mailed until after the end of the THREE-MONTH shortened statutory period, then the shortened statutory period will expire on the date the advisory action is mailed, and any extension fee pursuant to 37 CFR 1.136(a) will be calculated from the mailing date of the advisory action. In no event, however, will the statutory period for reply expire later than SIX MONTHS from the mailing date of this final action.

6. Any inquiry concerning this communication or earlier communications from the examiner should be directed to Ex. Skaggs whose telephone number is (703) 308-1113 and whose group fax number is (703) 305-7687.

hgs

H. GRANT SKAGGS
PRIMARY EXAMINER

February 14, 2002

APPENDIX 4

CERTIFICATE OF MAILING

I hereby certify that this correspondence is being deposited with the United States Postal Service as first class mail, with sufficient postage, in an envelope addressed to: Assistant Commissioner for Patents, Washington D.C. 20231, on

June 13, 2002
Date of Deposit

Kathleen K. Bowen
Name of Applicant, Assignee, or Registered Representative

Signature

June 13, 2002
Date of Signature

Attorney Docket No. 2000009

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Application of:

Michael T. Dobbertin and
Henry P. Mitchell, Jr.

Serial No. 09/688,001

Filing Date: October 14, 2000

For PULSED AIRKNIFE CONTROL FOR VACUUM CORRUGATED FEED SUPPLY

Examiner H. Grant Skaggs

Group Art Unit No. 3651

Assistant Commissioner for Patents
Washington, D.C. 20231

Dear Sir:

In response to the office action mailed on February 15, 2001:

Claim 5 stands rejected under 35 U.S.C. 103 (a) as being unpatentable over Yoshida et al in view of Jantsch et al. Claims 1-4 stand rejected under 35

U.S.C. 103 (a) as being unpatentable over Yoshida et al in view of Jantsch et al as applied to claim 5, and further in view of Watkiss. Applicants respectfully submit that for the following reasons, claim 5 is not obvious by Yoshida et al in view of Jantsch et al under 35 U.S.C. 103 (a) and claims 1-4 are not obvious by Yoshida et al in view of Jantsch et al as applied to claim 5, and further in view of Watkiss under 35 U.S.C. 103 (a). Applicants respectfully request reconsideration and further examination of claims 1-5.

In his rejection of claim 5, the Examiner states that "Yoshida et al shows in Fig. 34 the timed operation of a vacuum belt feeder which includes first opening a vacuum valve 13 (at c) and a positive pressure air valve 22 (at a), closing the pressure air valve (at b), driving the belt feeder (14), closing the vacuum (at d), and then turning off the drive to the belt." Applicant respectfully submits that this is in error. Applicants argued that Figure 34 in Yoshida et al does not show a positive pressure air valve either opening OR closing, what it does show is the position of the positive pressure air valve switching from position a to position b. Examiner further states that "Merely having the vacuum belt of Yoshida et al run until after the feed belt is de-energized would require mere choice or expedience since it would appear that the apparatus run equally well with the vacuum turned off after the de-energizing of the belt (14)." Applicant respectfully submits that the Examiner's observation has not been established as fact, and there is no factual support in the record for such an observation. Applicant respectfully requests that Examiner supply a factual support in the record for such an observation so that applicant can adequately respond. In the final rejection the Examiner responded by stating that the timing chart of Figure 34 could apply to the embodiments of Figs. 25-28. Applicants respectfully submit this is in error.

The timing chart of Figure 34 could not apply to the embodiments of Figs. 25-28, because applying the embodiments of Figures 25-28 to the timing chart of Fig 34 does not produce the "blow amount of nozzle 19" presented in Figure 34. For example, in Figs. 25-38, when the pressure air valve 22 is in the closed position b there would be no airflow through nozzle 19. Figure 34 clearly shows

that when valve 22 is in position b that there is non-zero airflow Q1 in nozzle 19; and further that the airflow through nozzle 19 is greater when the valve 22 is in position b than when it is position a. This clearly contradicts the Examiner's position that the timing chart of Figure 34 could apply to embodiments 25-28. Claim 5 is not obvious by Yoshida et al in view of Jantsch et al under 35 U.S.C. 103 (a), and applicants respectfully submit that rejection of claim 5 on this basis is in error, and request that the rejection on this basis be withdrawn.

Claims 1-4 stand rejected as being unpatentable over Yoshida et al in view of Jantsch et al as applied to claim 5 above, and further in view of Watkiss. As noted above, the combination of Yoshida et al in view of Jantsch et al as applied to claim 5 above is in error, as such applicants respectfully submit this rejection as stated is in error, and request that the rejection on this basis be withdrawn.

Examiner further states that "It would be obvious in order to aid in separation of the sheets from the stack to have the positive air pressure from valve 22 of Yoshida et al delivered in pulses as made obvious by Watkiss." In Yoshida et al the valve 22 is switched to position a, then the vacuum valve is opened, then valve 22 is switched to position b "to stop the injection of the air", and the convey belt is actuated. (see column 18 lines 1-8 and lines 37-44). In contrast, Watkiss has the positive air being pulsed "in synchronism with the operation of the vacuum device and the belt movement". Thus in Yoshida et al, the positive air is stopped when the belt is actuated, and in Watkiss the positive air is turned ON when the belt is actuated. Thus they directly conflict with each other, so not only is there no motivation to combine Yoshida et al and Watkiss, but it could not be done. Applicants respectfully submit that rejection of claims 1-4 on this basis is in error, and respectfully request rejection on this basis be withdrawn.

Examiner further states that with regard to claims 2-3, "merely having the air pressure separator (at a of 22 of Fig. 34) of Yoshida et al actuated at the same time as the vacuum is actuated (at 13 c of Fig 34) would require mere

choice or expedience since the apparatus of Yoshida et al could work equally well with this type of timed operation". Examiner further states that "Examiner has made a factual observation of the modified Yoshida et al apparatus and the burden is on applicant to refute such observations." Applicant respectfully submits that the Examiner's observation has not been established as fact, and there is no factual support in the record for such an observation. Applicant respectfully requests that Examiner supply a factual support in the record for, such an observation so that applicant can adequately respond. Further, with regard to claim 2, the Examiner speaks to the limitation of having the positive air pressure separator actuated when the vacuum is actuated, however, the Examiner does not address the limitation of the "positive air pressure is de-actuated before the feed clutch is energized." If the Examiner is relying on the timing chart Figure 34 of Yoshida et al for this limitation, applicant respectfully submits that for the reasons stated in the above paragraph, Figure 34 of Yoshida et al is not applicable. In the absence of such, applicants respectfully submit that rejection of claims 2-3 on this basis is in error, and respectfully request rejection on this basis be withdrawn.

Examiner further states with regard to claims 3 and 4, that "to have the time between the closing of the valve 22 (at b) and the activation of the feed belt 14 of Yoshida et al to be approximately 50 milliseconds would require mere choice of expedience based on the timing of the feed rate of the sheets being fed". Examiner further states that "Examiner has made a factual observation of the modified Yoshida et al apparatus and the burden is on applicant to refute such observations." Applicant respectfully submits that the Examiner's observation has not been established as fact, and that there is no factual support in the record for such an observation. Applicant respectfully requests that Examiner supply a factual support in the record for such an observation so that applicant can adequately respond. In the absence of such, applicants respectfully submit that rejection of claims 3-4 on this basis is in error, and respectfully request rejection on this basis be withdrawn.

Applicants respectfully submit that claims 1-5 are allowable as written, and request that the rejections against them be withdrawn.

Respectfully submitted,

Kathleen K. Bowen, Esq.
Registration No. 42,352
Attorney for Applicants

APPENDIX 5

US005478066A

United States Patent [19]

Yoshida et al.

[11] Patent Number: 5,478,066

[45] Date of Patent: Dec. 26, 1995

[54] **SHEET SUPPLY APPARATUS**

[75] Inventors: Yasumi Yoshida, Kawasaki; Makoto Tanaka, Tokyo; Hiroyuki Takahara, Kawasaki; Takeshi Aoyama, Yokohama; Ryusei Kominato, Tokyo; Shinsuke Ubayashi, Yokohama, all of Japan

[73] Assignee: Canon Kabushiki Kaisha, Tokyo, Japan

[21] Appl. No.: 144,260

[22] Filed: Nov. 1, 1993

[30] Foreign Application Priority Data

Nov. 2, 1992	[JP]	Japan	4-317887
Dec. 28, 1992	[JP]	Japan	4-361205
Dec. 29, 1992	[JP]	Japan	4-361273
Feb. 19, 1993	[JP]	Japan	5-055096
Mar. 3, 1993	[JP]	Japan	5-067452

[51] Int. Cl.[6] B65H 5/08

[52] U.S. Cl. 271/12; 271/94; 271/96; 271/99; 271/104; 271/105; 271/106; 271/108; 271/263; 271/902

[58] Field of Search 271/94, 96, 98, 271/99, 104, 105, 106, 108, 122, 265, 263, 258, 11, 12, 902

[56] References Cited

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4-358637	12/1992	Japan .	
4358637	12/1992	Japan	271/94

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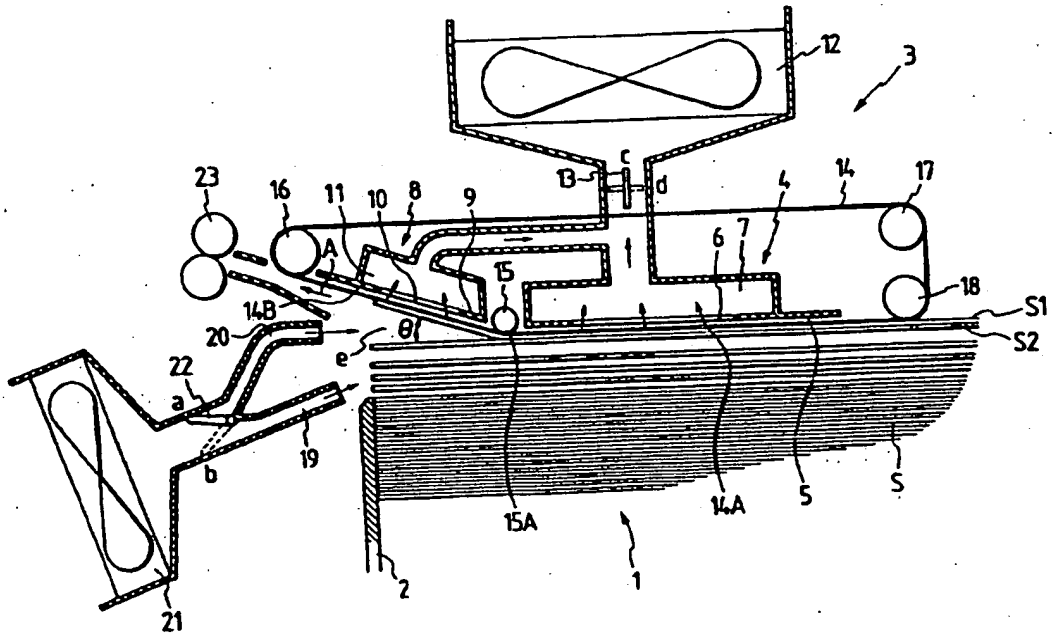
Anderson et al., Document Feeder and Separator, IBM Technical Disclosure Bulletin, vol. 6 No. 2, pp. 32–33, 1963.

Primary Examiner—William E. Terrell
Assistant Examiner—Carol L. Druzbick
Attorney, Agent, or Firm—Fitzpatrick, Cella, Harper & Scinto

[57] ABSTRACT

The present invention provides a sheet supply apparatus with a sheet support for supporting a plurality of sheets, a first sheet absorb unit arranged facing a sheet surface of the sheet stack supported by the sheet support for absorbing the sheet by air suction, a second sheet absorb unit arranged facing a tip end of the sheet stack in a sheet supply direction for absorbing the sheet by air suction and a conveyer for conveying the sheet absorbed to the first and second sheet absorb units. The first sheet absorb unit and the second sheet absorb unit are respectively disposed at positions where the first sheet absorb unit is substantially parallel to the sheet surface and the second sheet absorb unit is inclined relative to the sheet surface. When a sheet stops a feeding unit operates in response to return the sheet to the sheet stack as the sheet is being absorbed by the first sheet absorb unit.

24 Claims, 50 Drawing Sheets



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CCC38 XR 5,478,066

T AND TRADEMARK OFFICE

CERTIFICATE OF CORRECTION

PATENT NO. : 5,478,066 Page 1 of 2

DATED : December 26, 1995

INVENTOR(S) : YASUMI YOSHIDA, ET AL.

It is certified that error appears in the above-indentified patent and that said Letters Patent is hereby corrected as shown below:

On title page, item [56], "4358637 12/1992 Japan" should be deleted,

"3079525 4/1991 Japan" should read --3-79525 4/1991 Japan--, and "4169433 6/1992 Japan" should read --4-169433 6/1992 Japan--.

Column 1,
line 29, "is" should read --are--.

Column 5,
line 59, "is" should read --are--.

Column 9,
line 65, "stack So" should read --stack S.--.

Column 15,
line 10, "fundamentary," should read --fundamentally,--.

Column 21,
line 28, "is" should read --are--.

UNITED STATES PATENT AND TRADEMARK OFFICE

CERTIFICATE OF CORRECTION

PATENT NO. : 5,478,066
DATED : December 26, 1995
INVENTOR(S) : YASUMI YOSHIDA, ET AL.

It is certified that error appears in the above-indentified patent and that said Letters Patent is hereby corrected as shown below:

Column 25,
line 45, "a" should be deleted; and
line 63, "belower" shoul dread --blower--.
Column 26,
line 16, "a" should be deleted.
Column 31,
line 17, "said sheet" should read --said first and second sheet--.

Signed and Sealed this

Seventeenth Day of September, 1996

Attest:

BRUCE LEHMAN

Attesting Officer

Commissioner of Patents and Trademarks

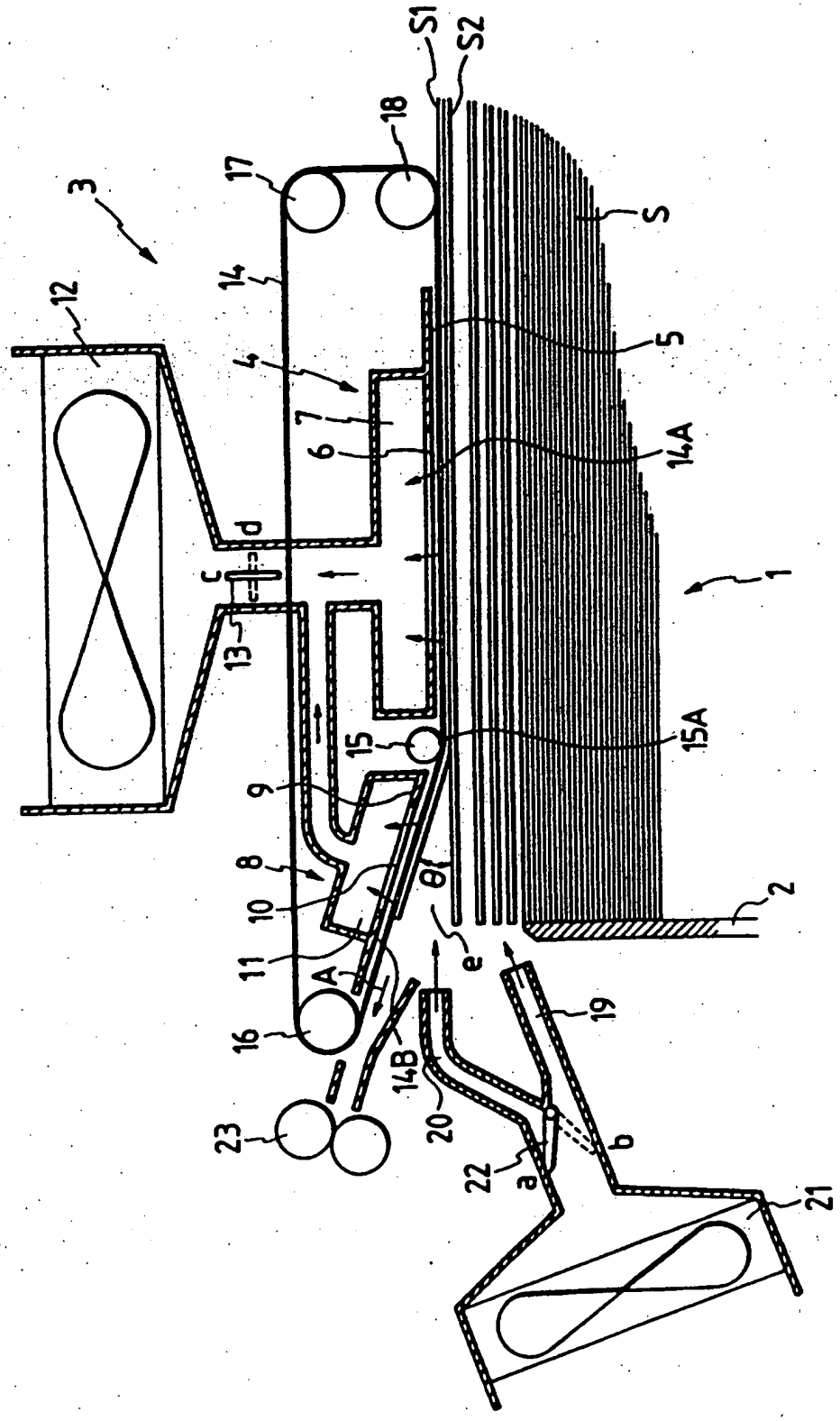
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FIG. 1

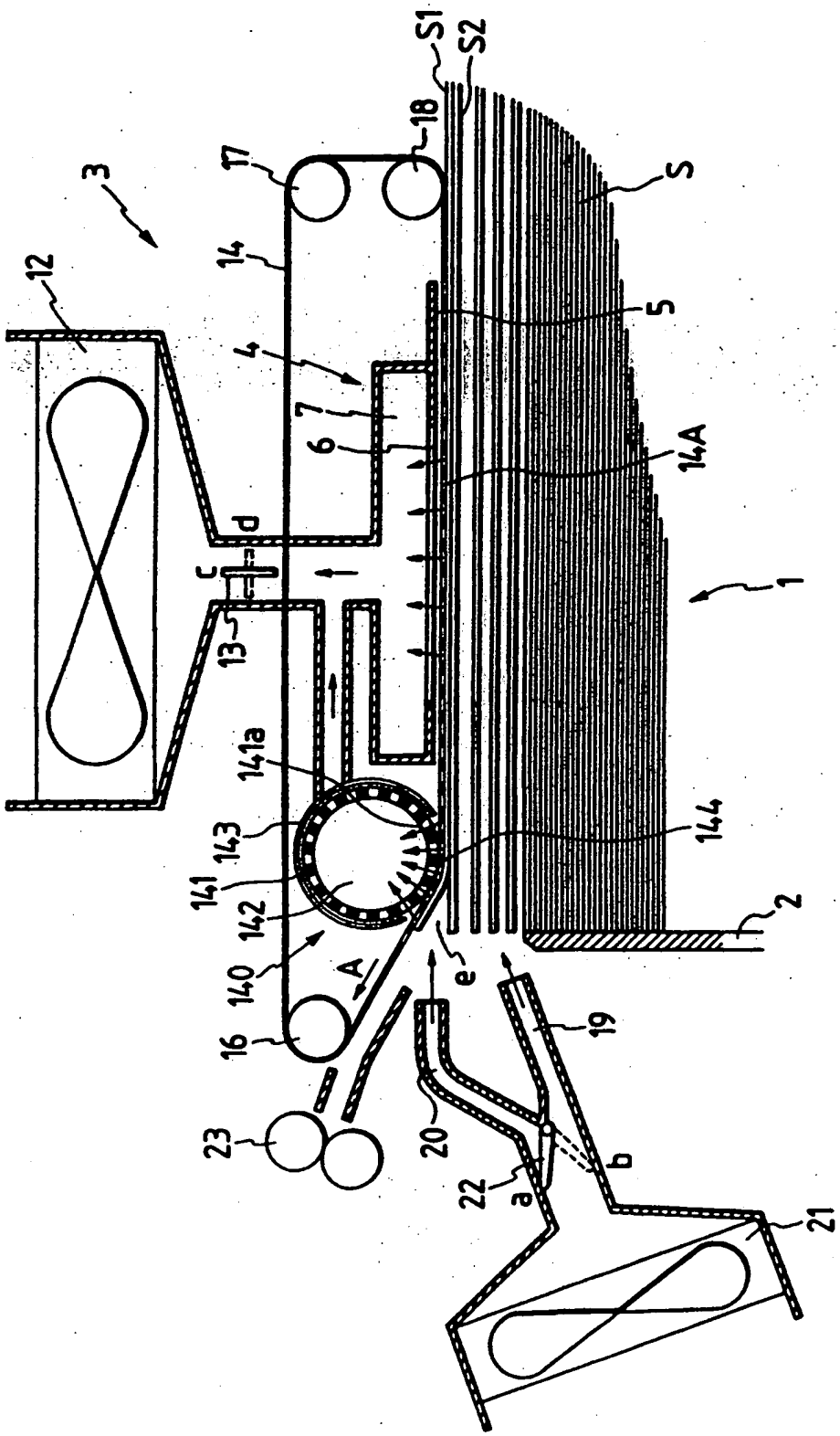
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FIG. 2

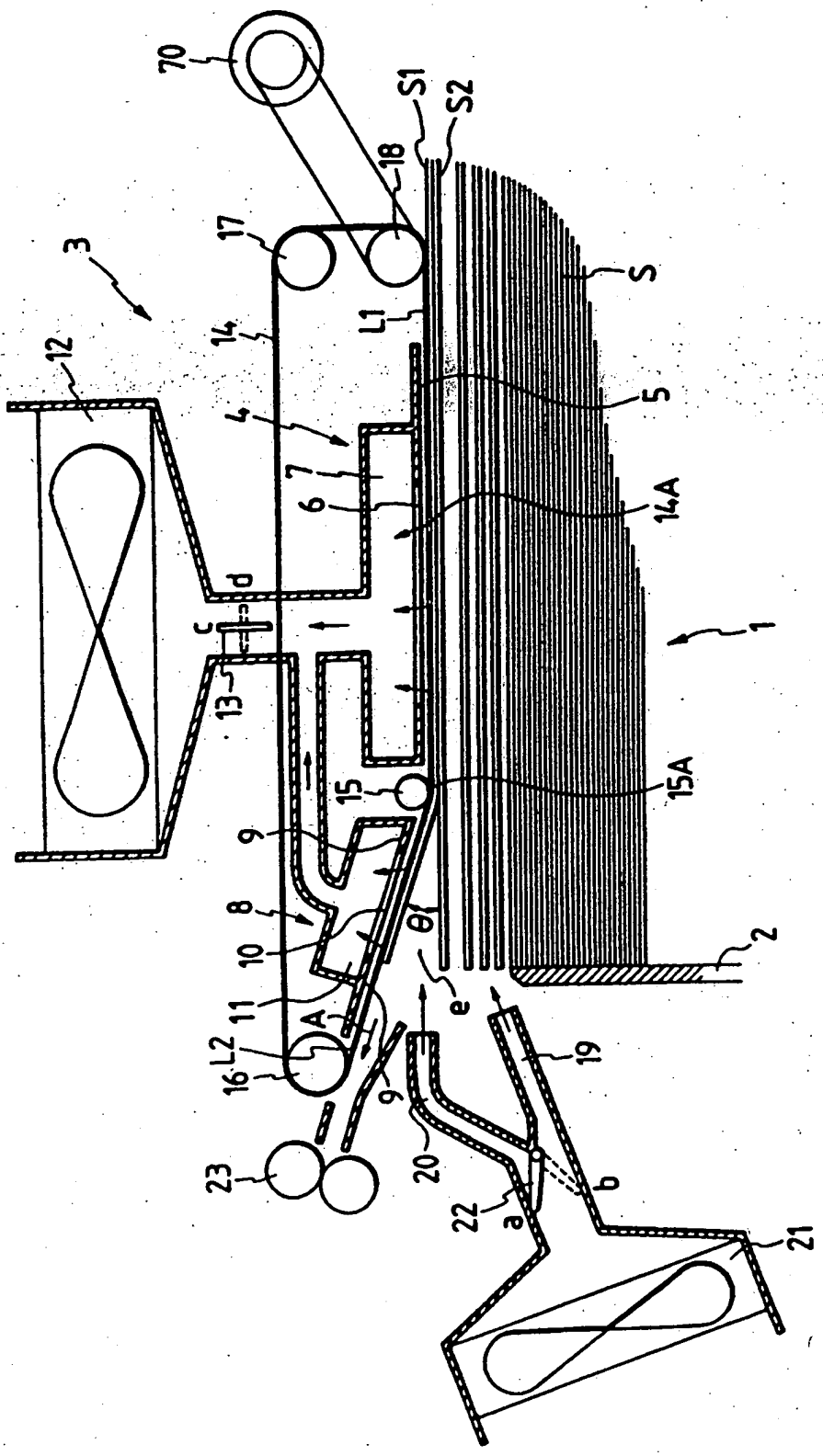
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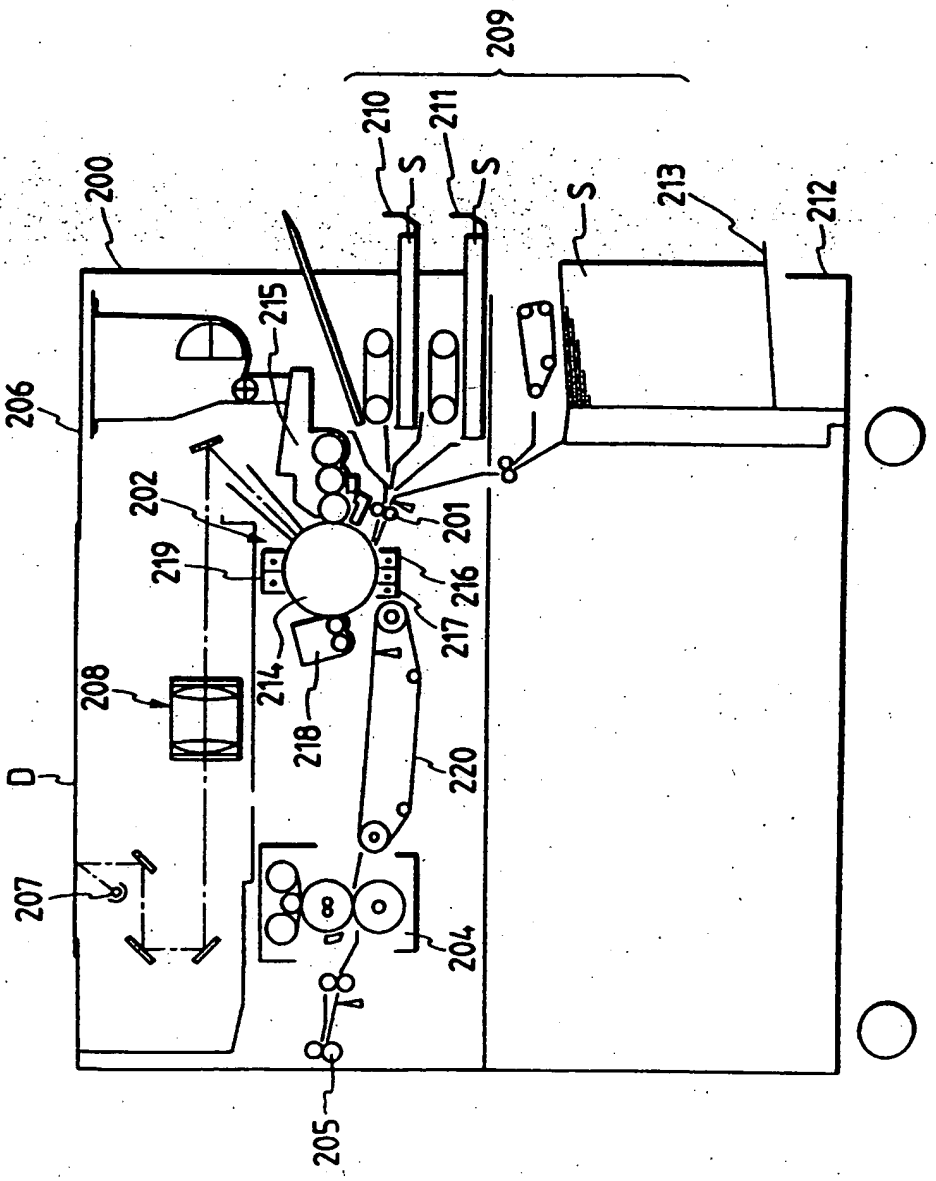
FIG. 3

FIG. 4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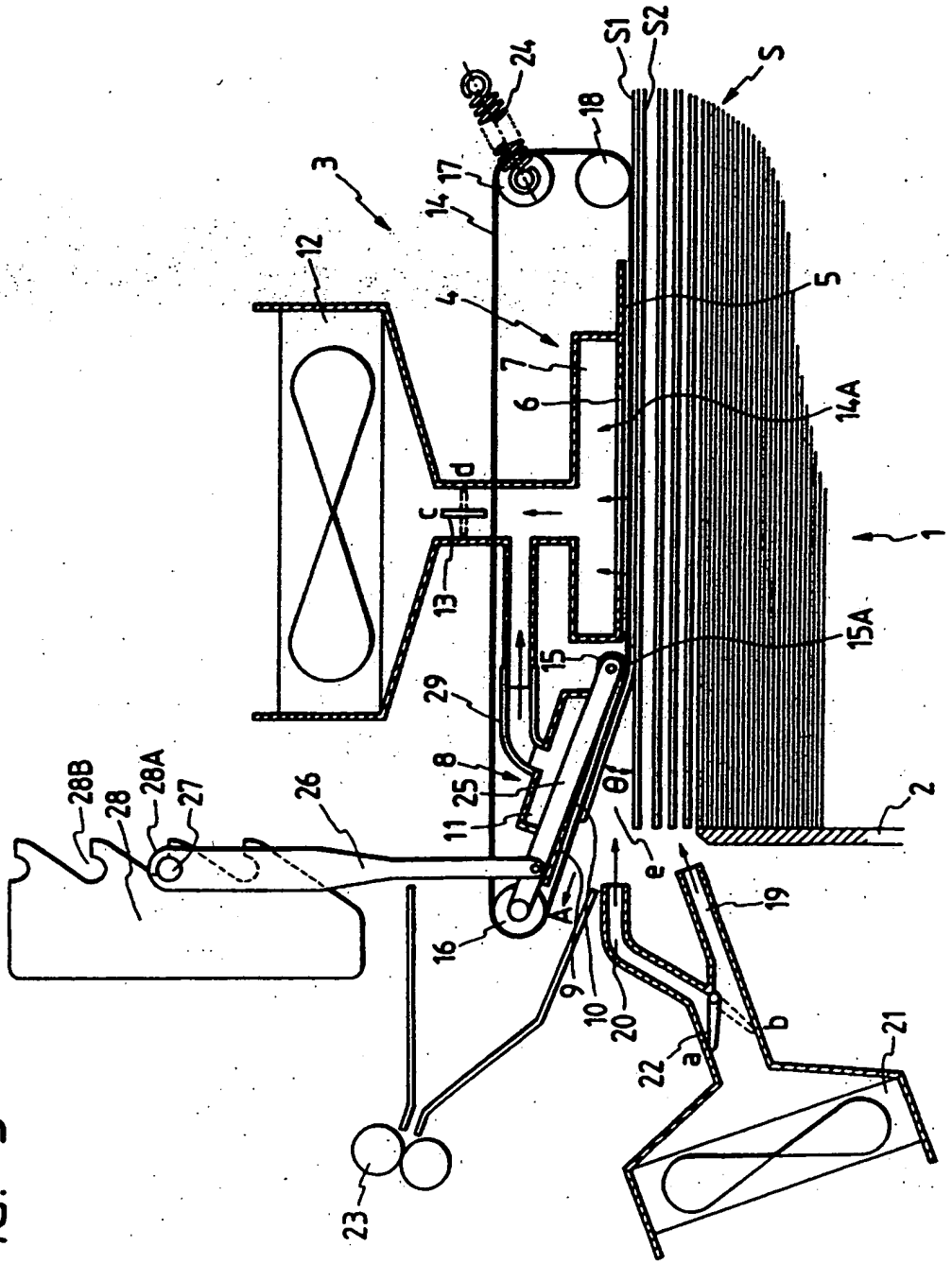

S1
S2
S
24
18
3
14
17
12
4
5
7
6
14A
d
c
13
1
15A
15
29
8
25
11
28B
28
28A
27
26
θ1
2
e
19
16
A
9
10
20
22
a
b
21
23

FIG. 5

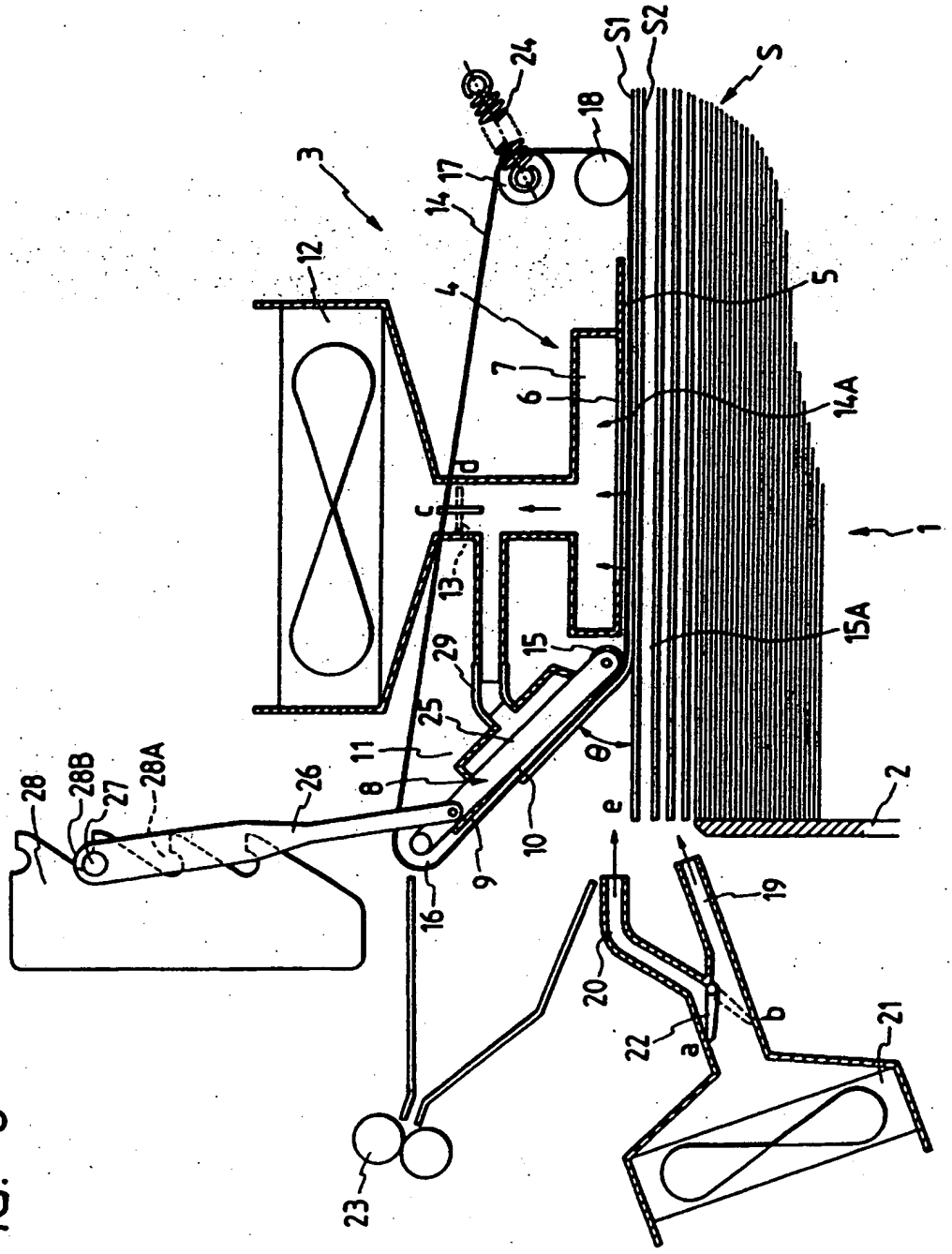

S1
S2
S
24
18
3
17
14
12
4
5
7
6
14A
d
c
1
13
15A
29
15
25
11
θ
8
28
28B
27
28A
26
2
10
e
9
16
19
20
22
a
b
21
23

FIG. 6

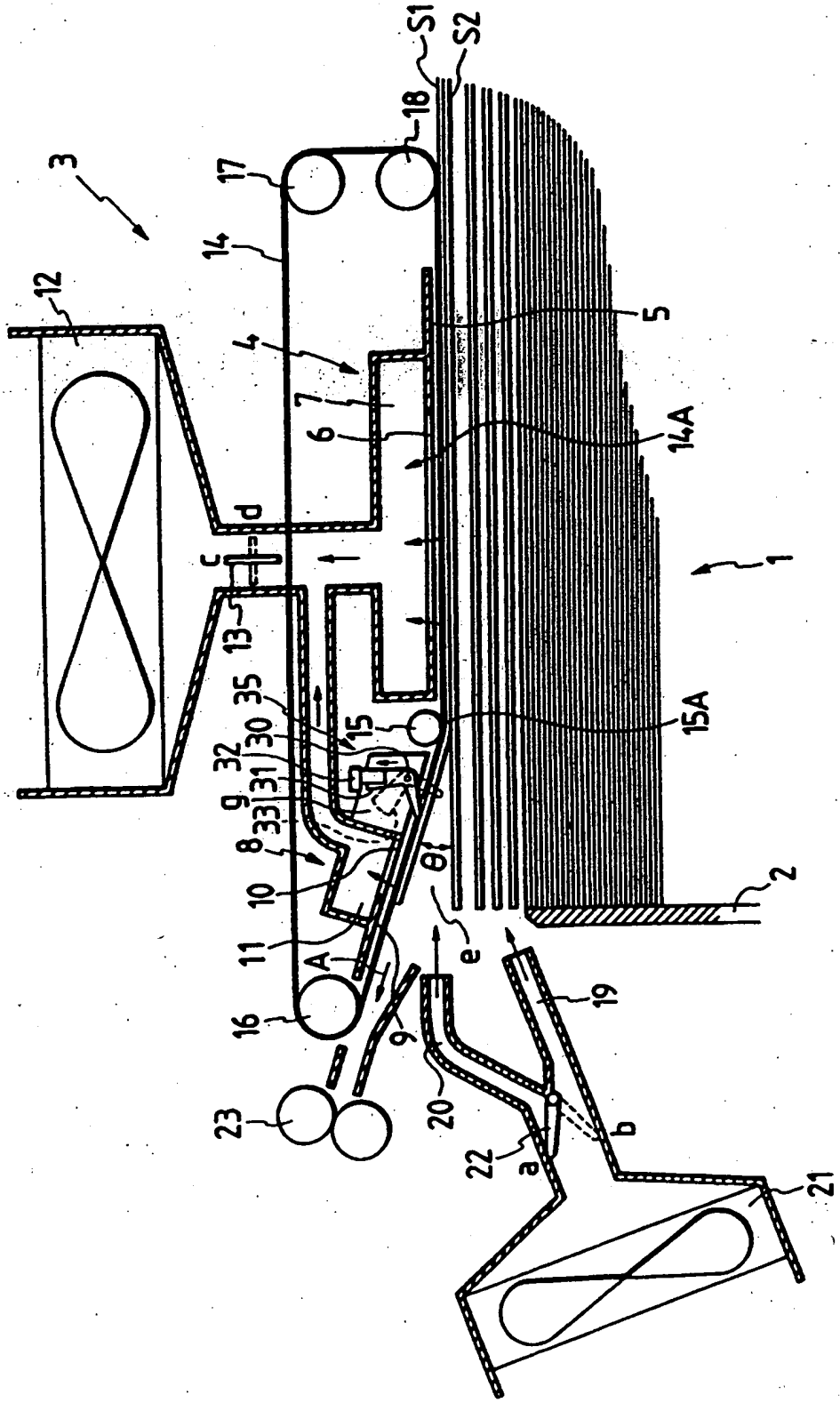

S1
S2
18
17
3
14
12
5
4
7
6
14A
d
c
1
13
35
30
15
15A
32
31
9
33
8
10
11
A
16
9
23
20
22
a
b
19
21
2
e
θ

FIG. 7

FIG. 8

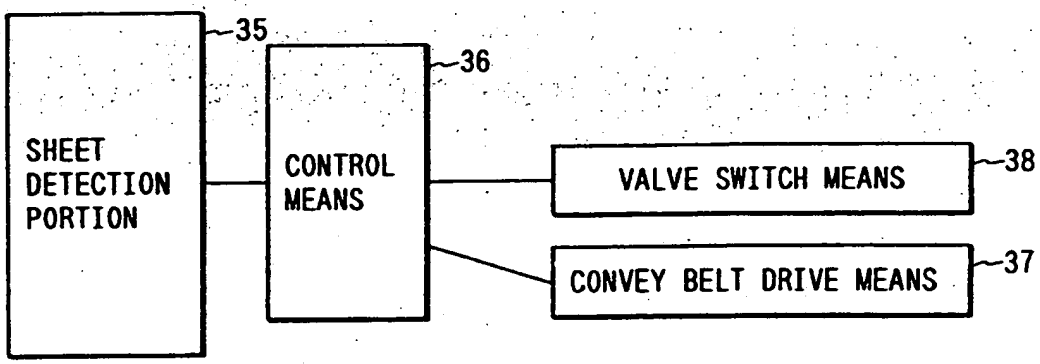
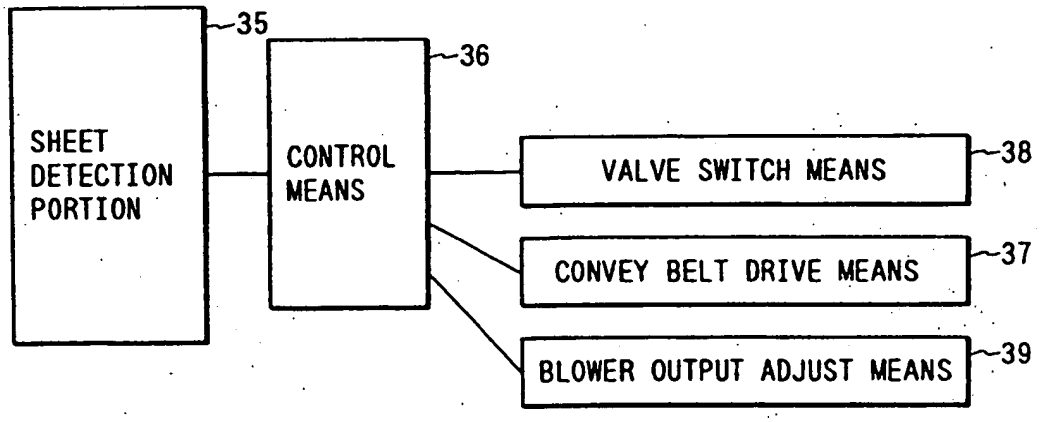

SHEET DETECTION PORTION
35
CONTROL MEANS
36
VALVE SWITCH MEANS
38
CONVEY BELT DRIVE MEANS
37

FIG. 9


SHEET DETECTION PORTION
35
CONTROL MEANS
36
VALVE SWITCH MEANS
38
CONVEY BELT DRIVE MEANS
37
BLOWER OUTPUT ADJUST MEANS
39

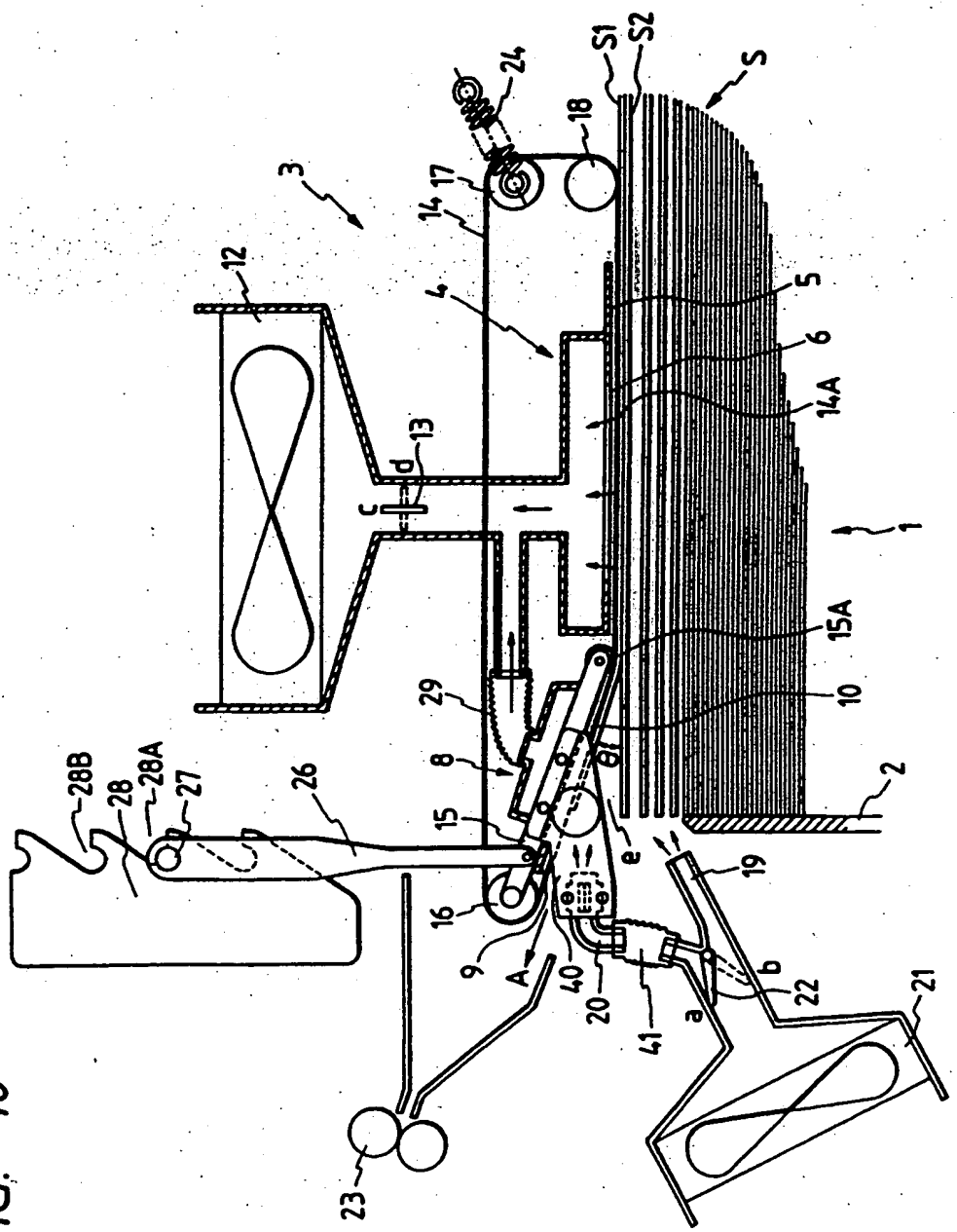

S1
S2
S
24
18
3
17
14
12
4
5
6
14A
13
d
c
1
15A
29
10
8
81
28B
28
28A
27
26
15
2
e
19
16
9
A
40
20
41
a
b
22
21
23

FIG. 10

FIG. 11

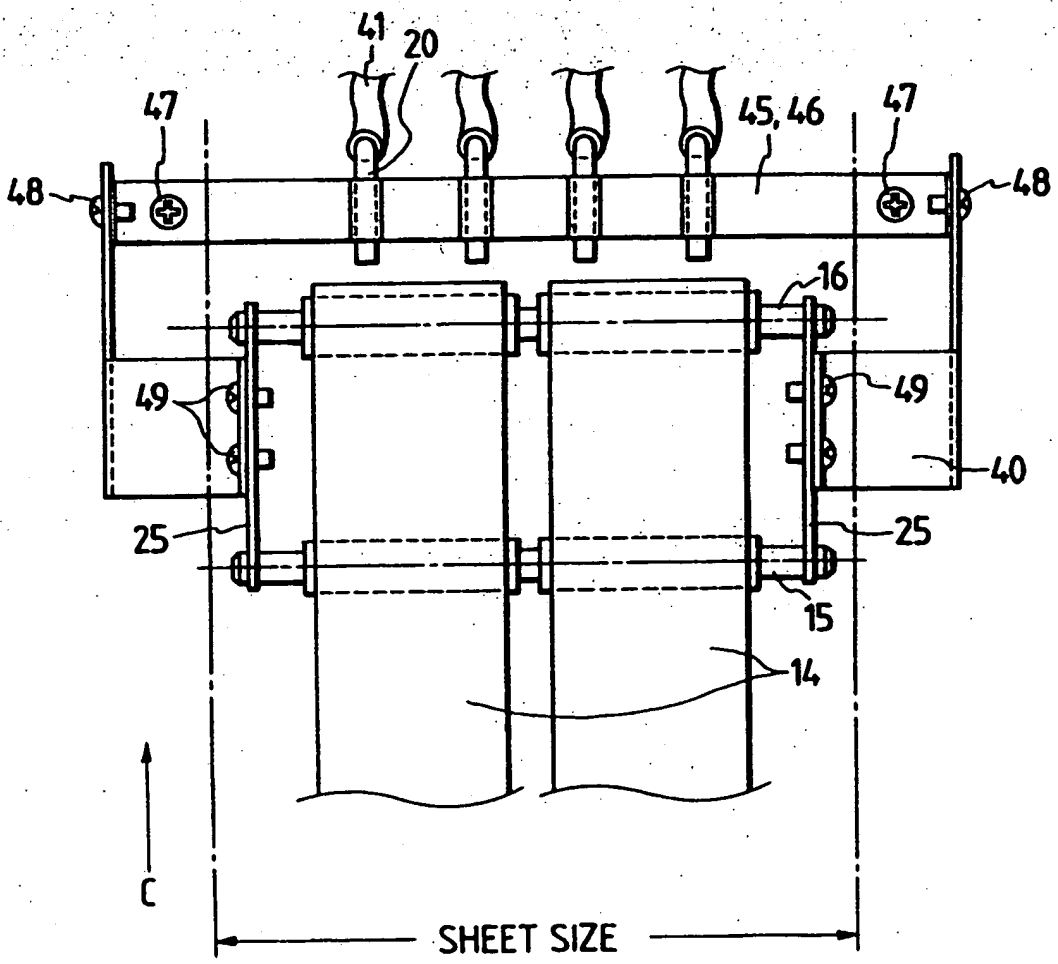
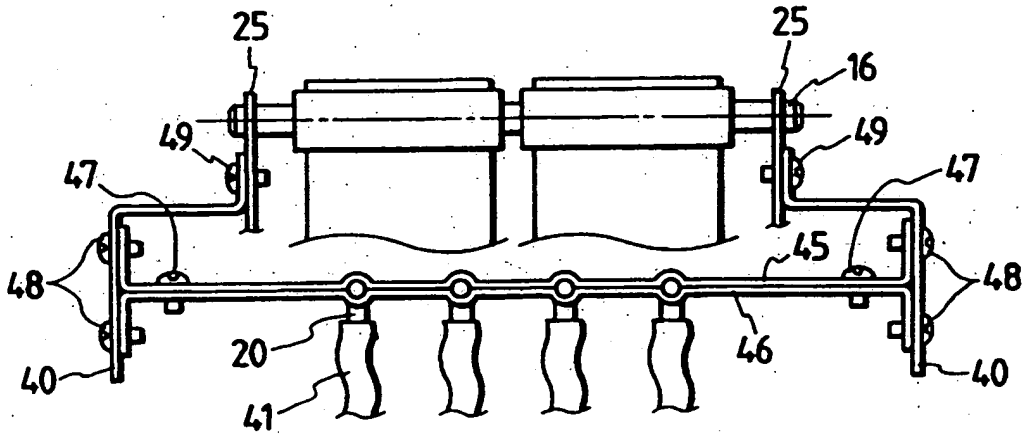


FIG. 12



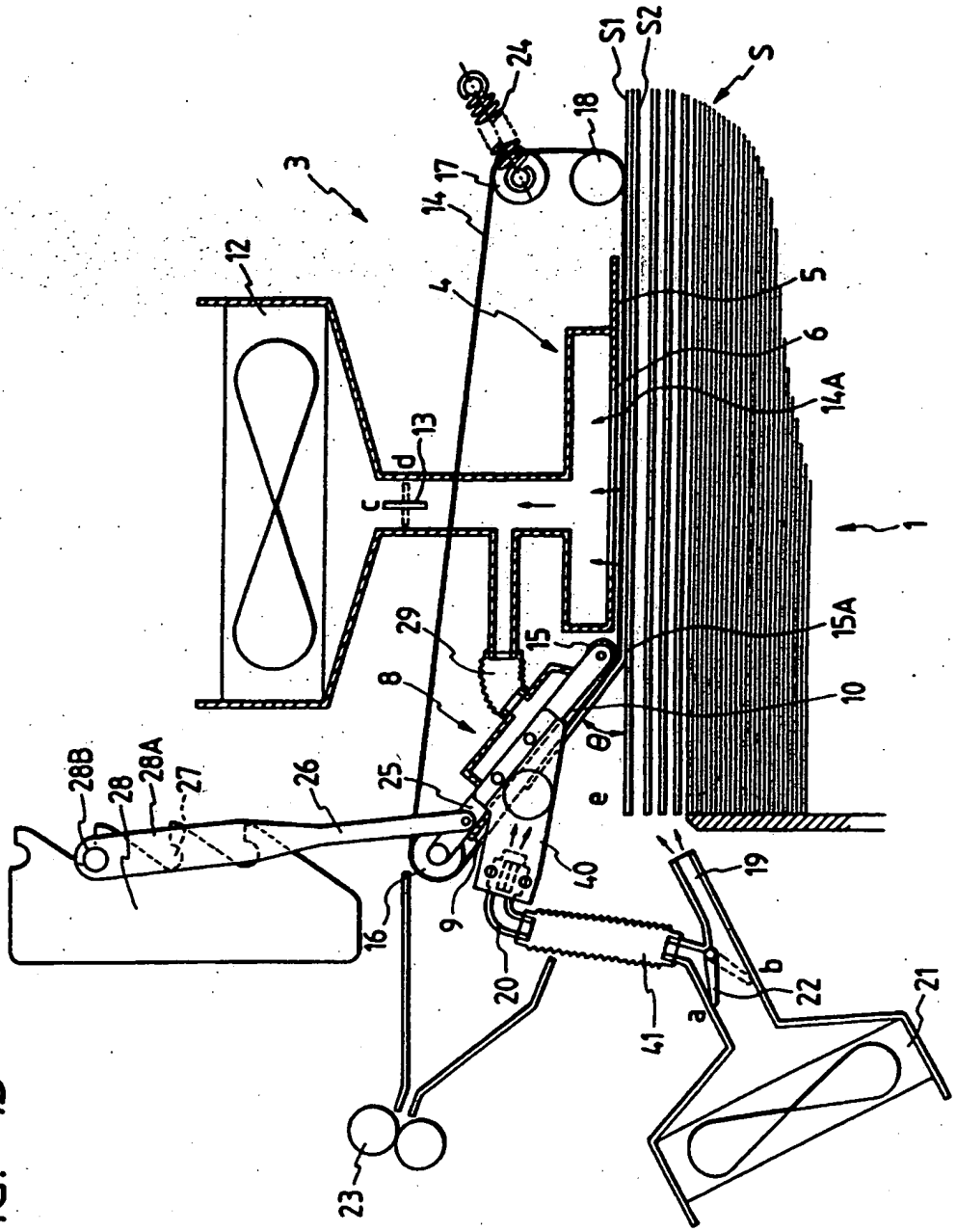

S1
S2
S
24
18
3
17
14
12
4
5
6
14A
13
d
c
1
29
15
15A
8
10
θ
28B
28
28A
27
26
25
e
40
19
16
9
20
b
22
21
41
a
23

FIG. 13

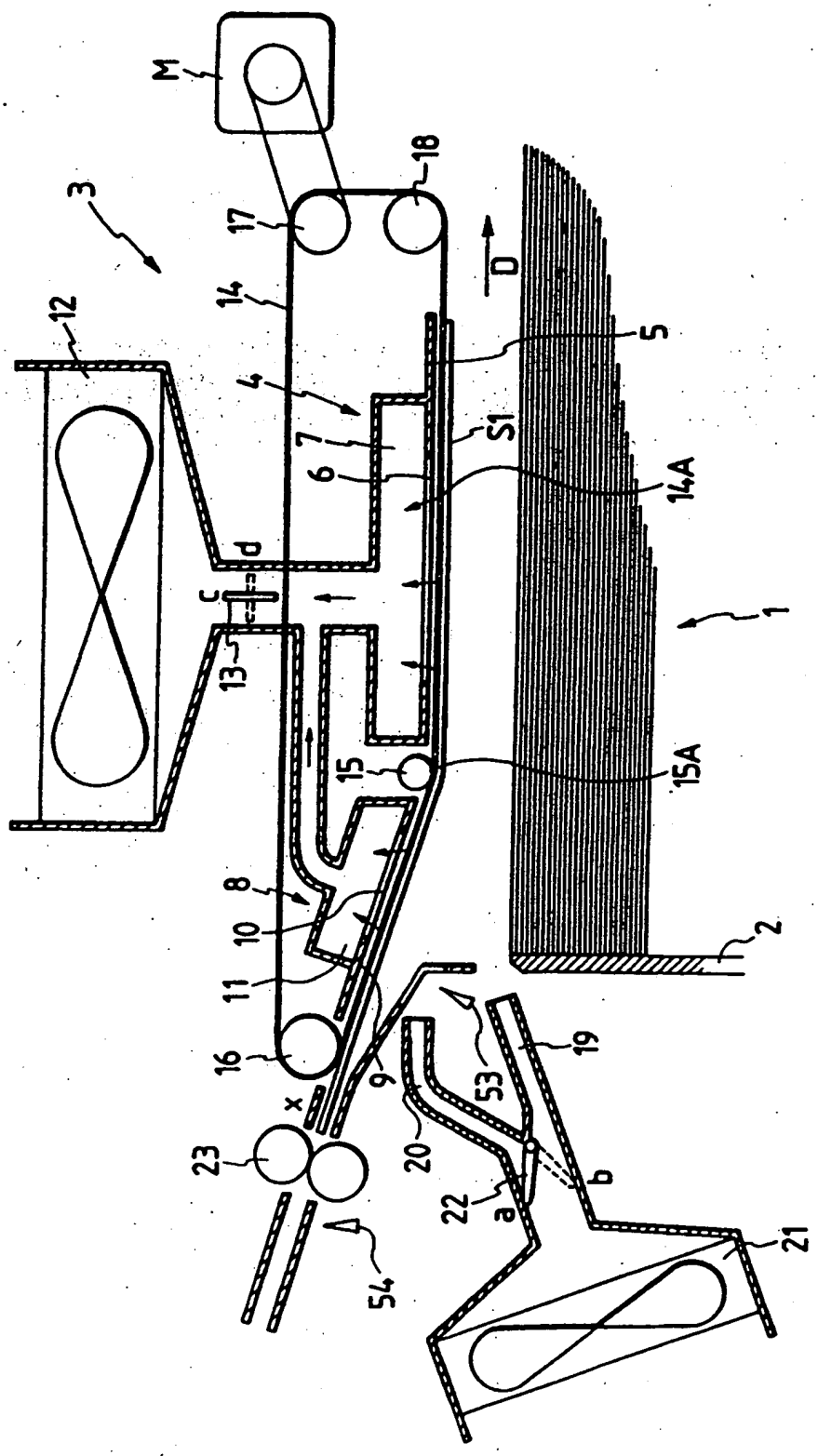

M
3
18
17
14
12
D
5
4
S1
7
6
14A
d
C
13
1
15
15A
8
10
11
2
16
9
53
19
x
23
20
22
a
b
21
54

FIG. 14

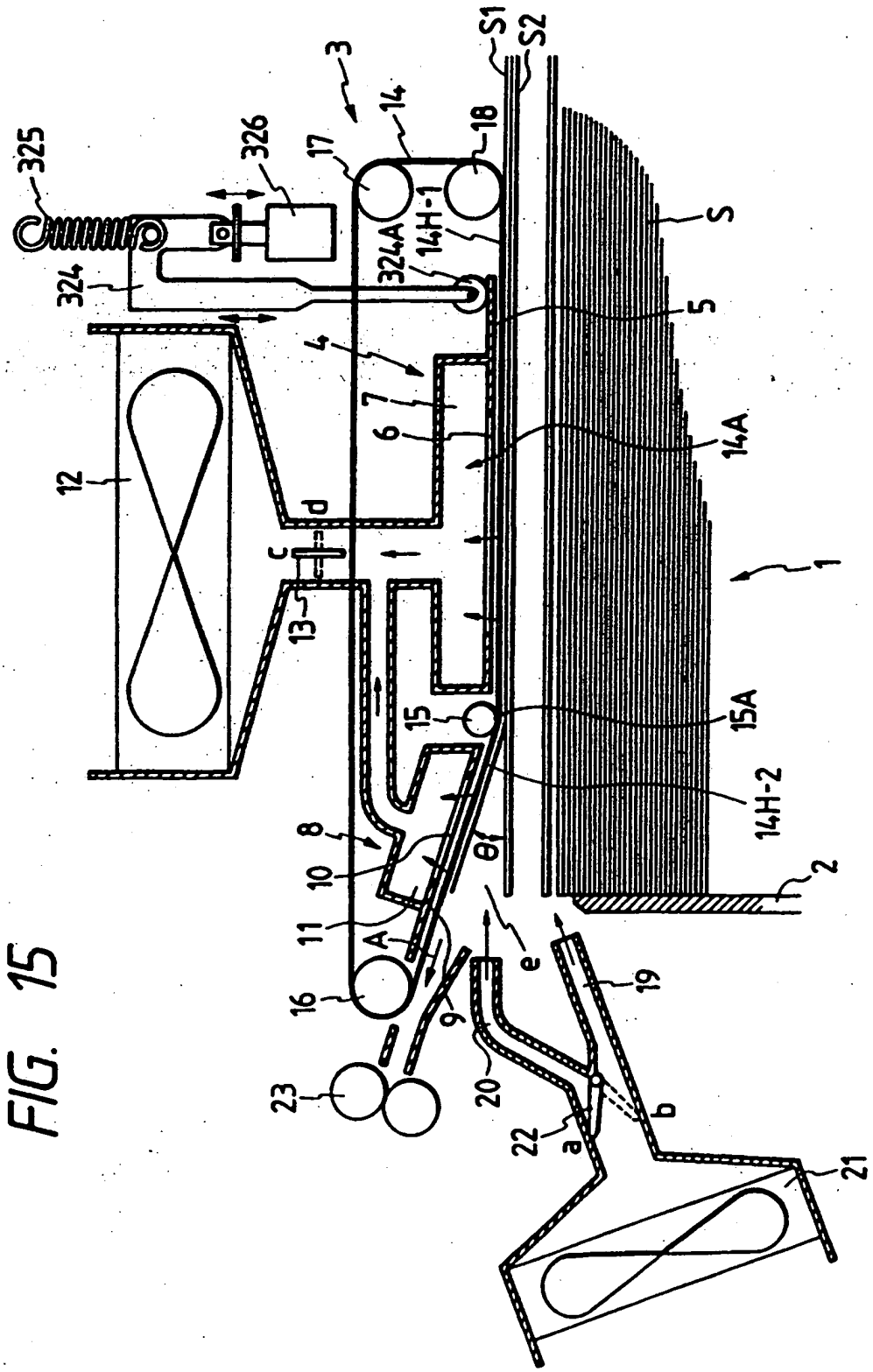

325
326
17
3
14
18
S1
S2
324
324A
14H-1
S
5
4
7
6
14A
12
d
c
13
1
15
15A
14H-2
8
10
11
A
θ
2
16
9
e
19
23
20
22
a
b
21

FIG. 15

FIG. 16A

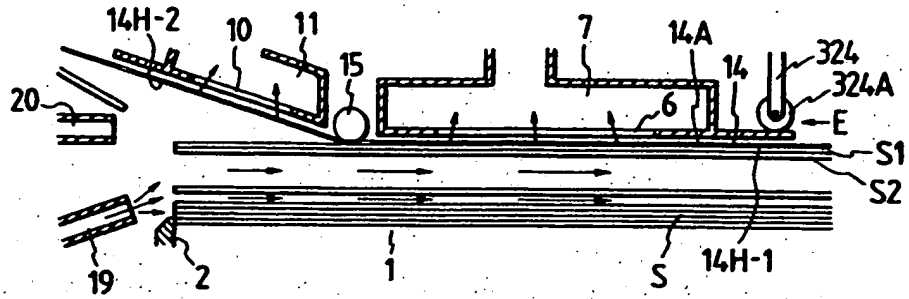


FIG. 16B

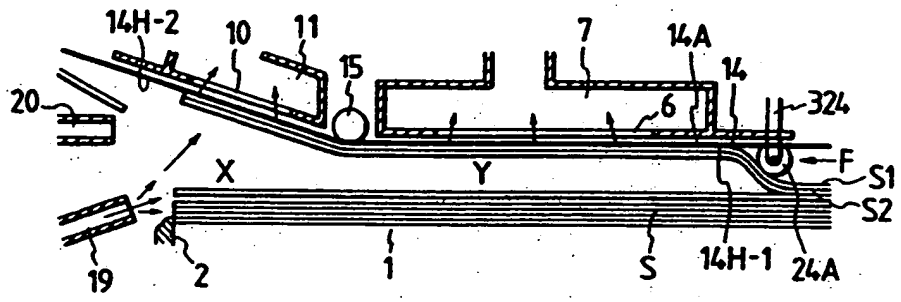


FIG. 16C

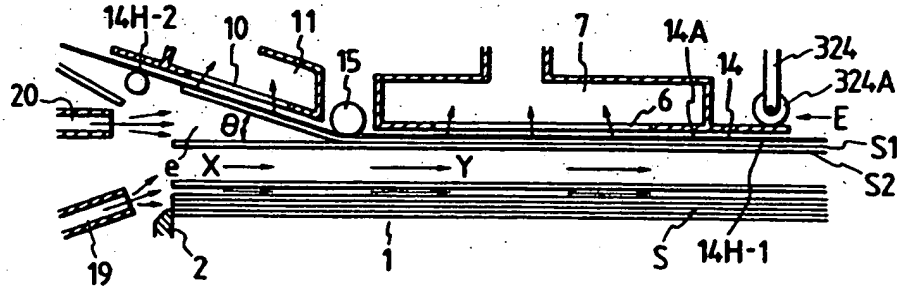
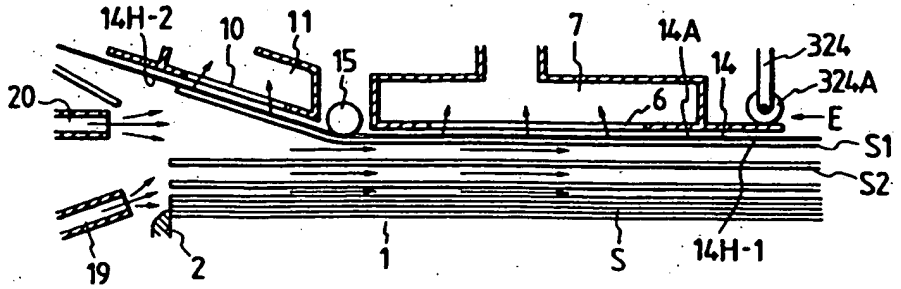


FIG. 16D



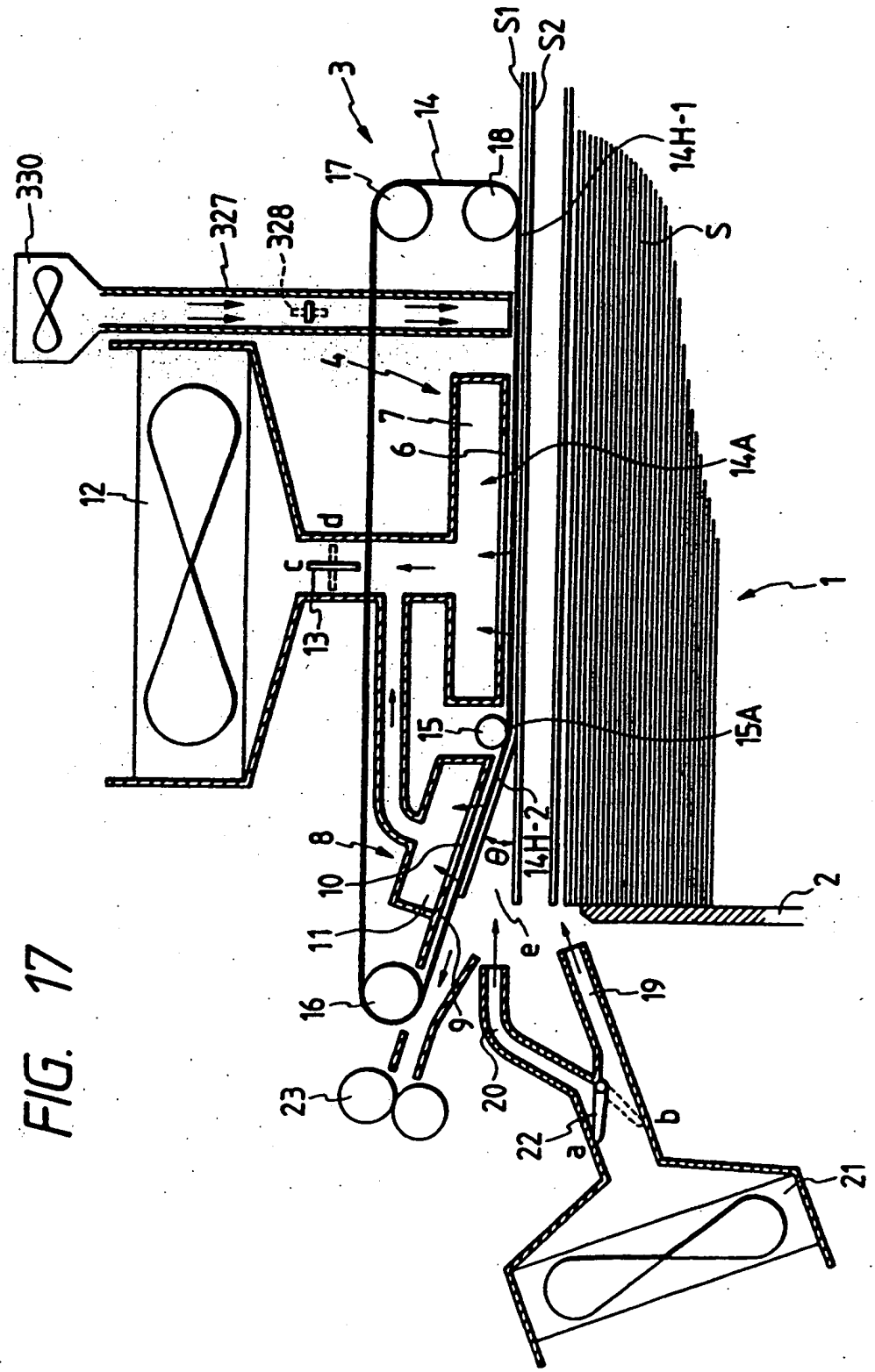

S1
S2
3
14
18
14H-1
17
330
327
328
S
4
7
6
14A
12
d
c
13
1
15
15A
14H-2
8
θ
10
2
11
e
19
16
9
20
23
22
a
b
21

FIG. 17

FIG. 18A

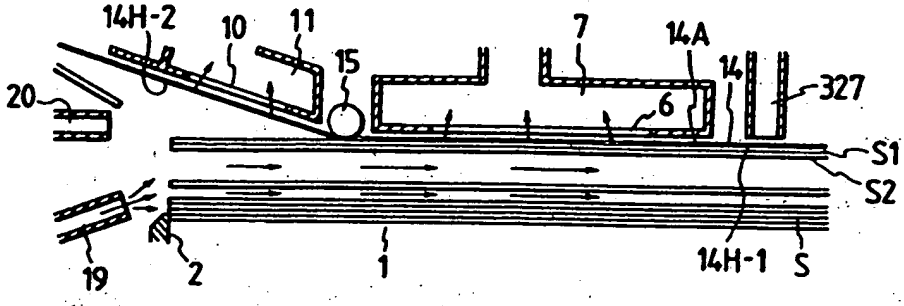


FIG. 18B

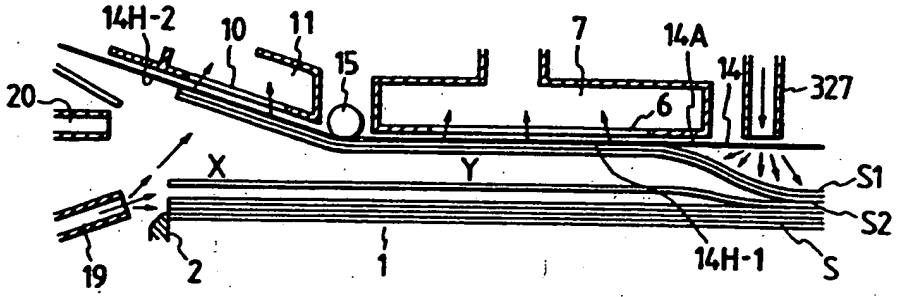


FIG. 18C

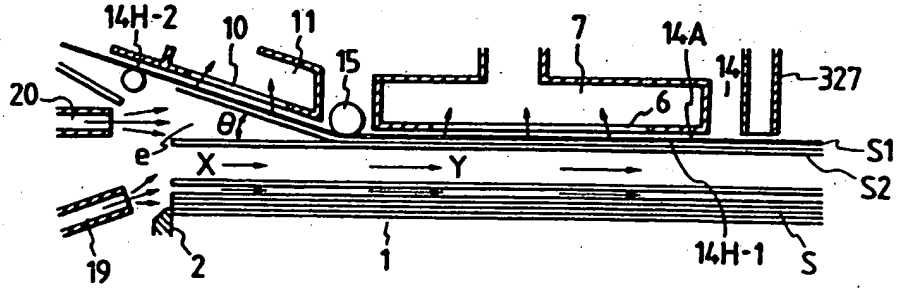
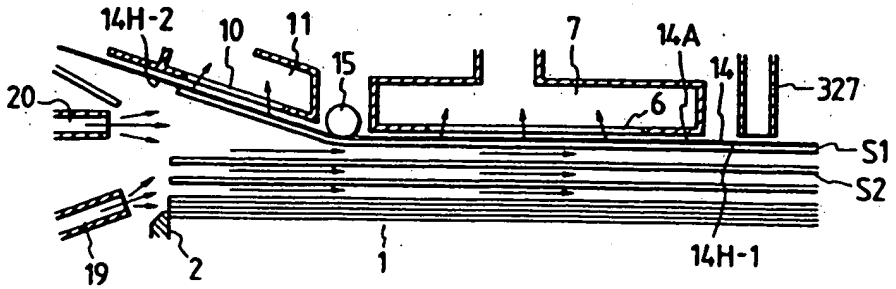


FIG. 18D



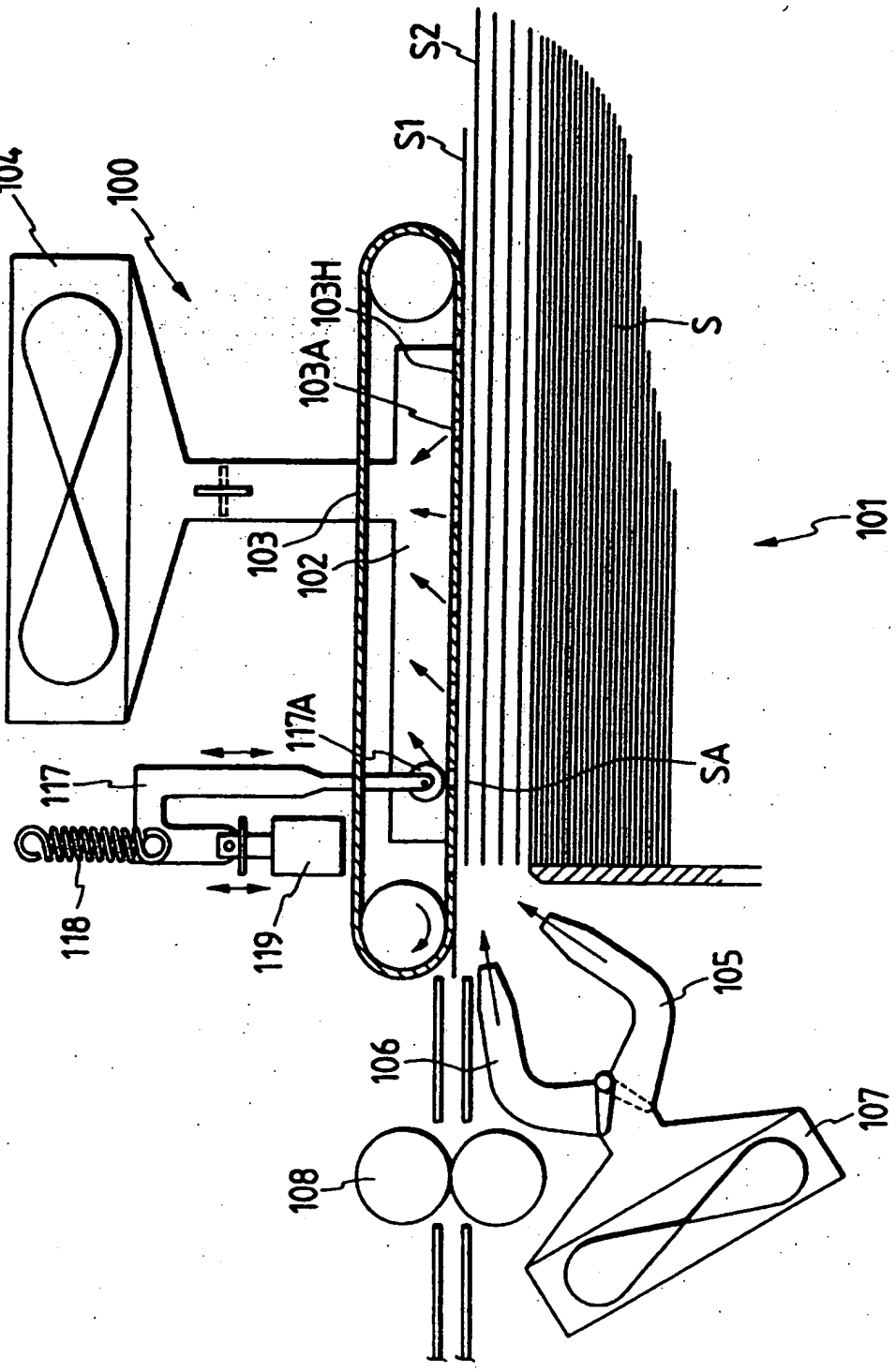

S2
S1
104
100
103H
103A
S
101
103
102
117A
117
SA
118
119
105
106
107
108

FIG. 19

FIG. 20A

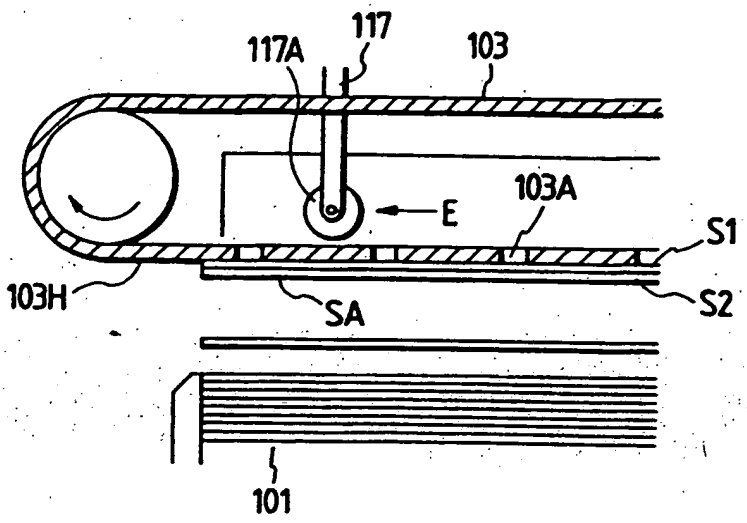


FIG. 20B

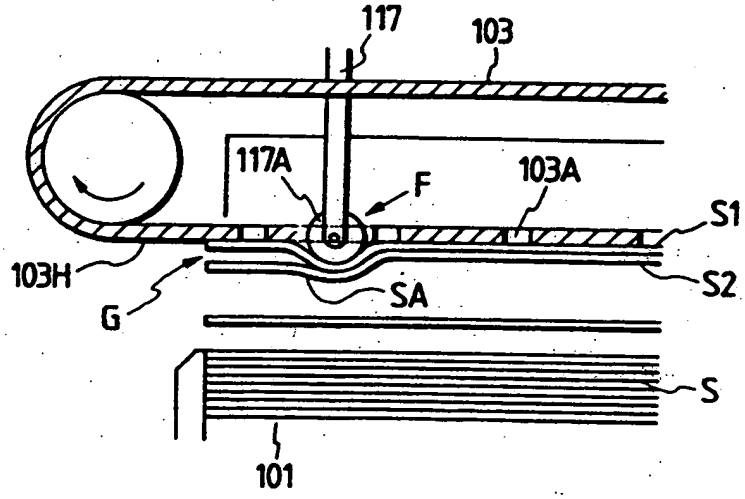
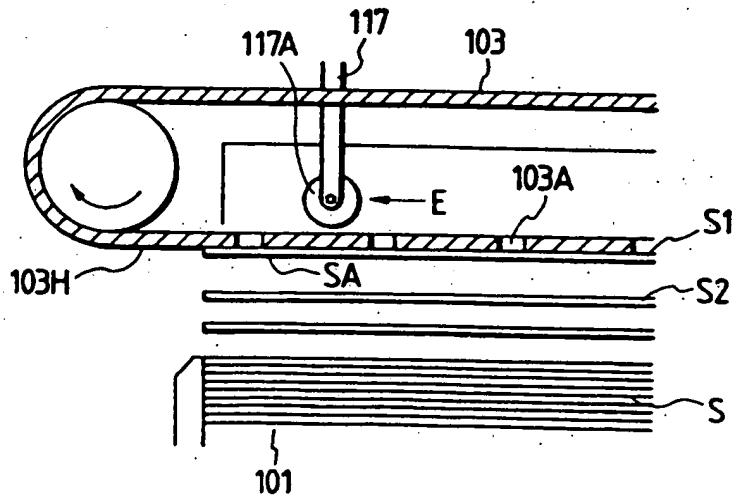


FIG. 20C



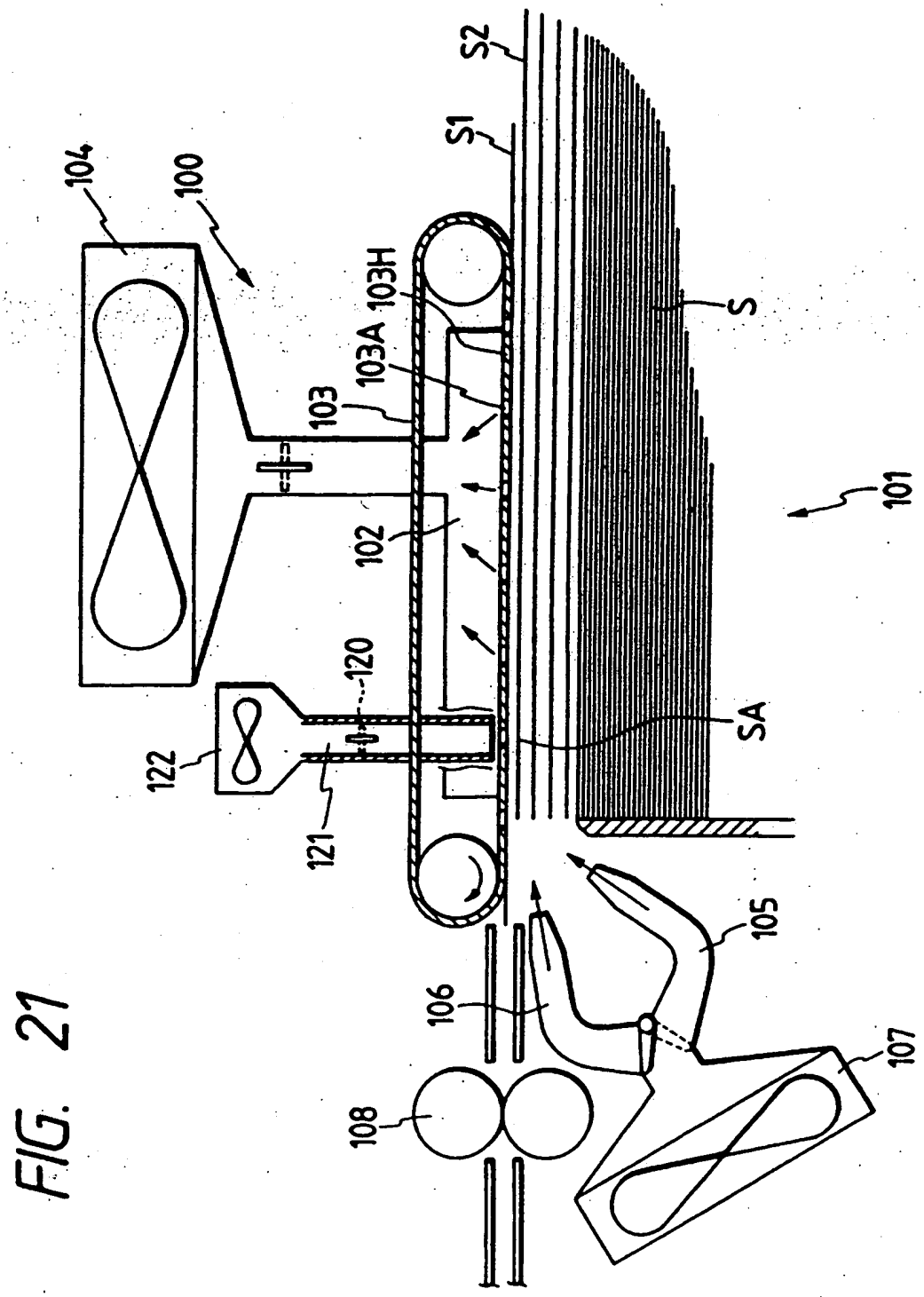

S2
S1
104
100
103H
S
103A
103
101
102
120
SA
122
121
105
106
107
108

FIG. 21

FIG. 22A

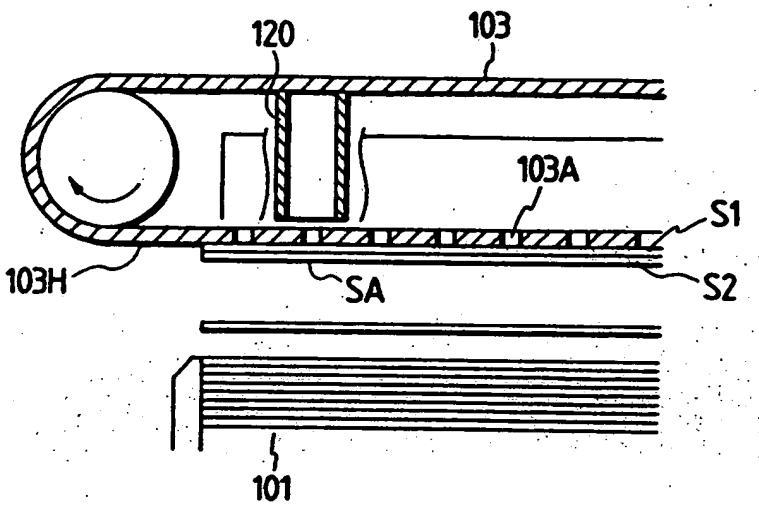


FIG. 22B

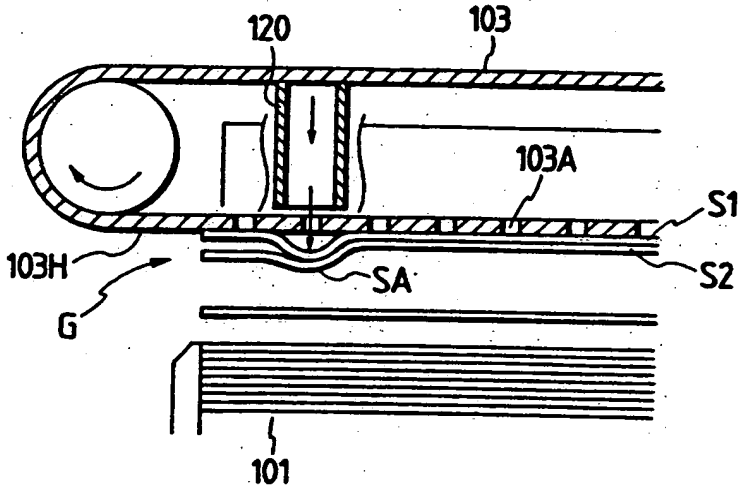
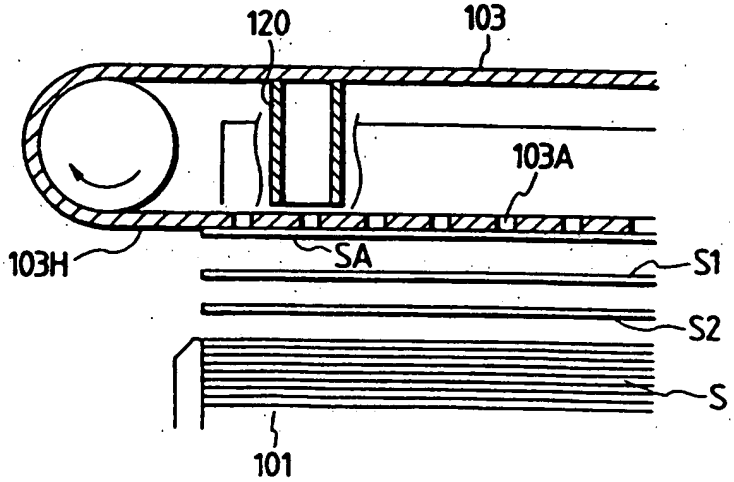


FIG. 22C



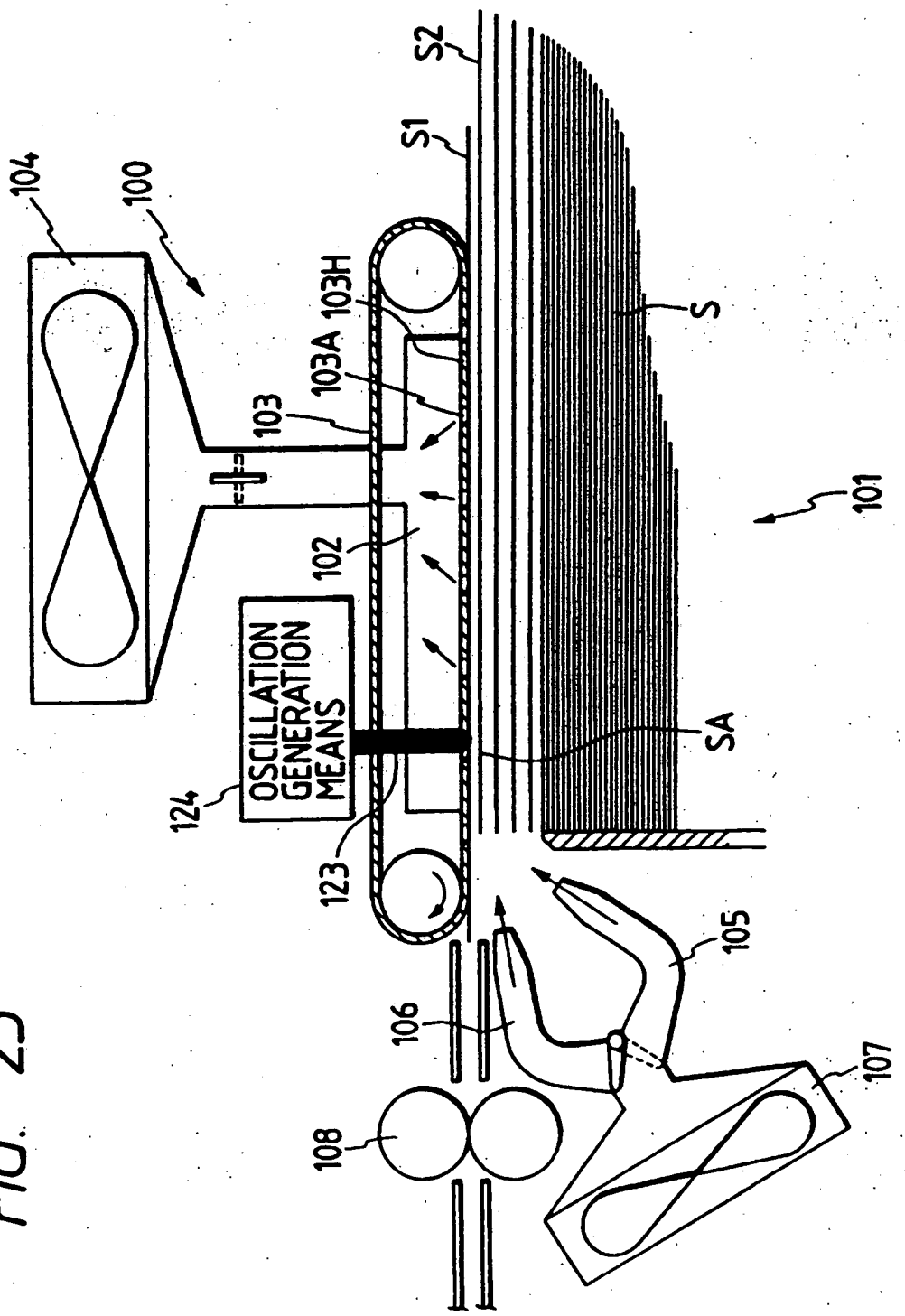

S2
S1
104
100
103H
S
103A
103
101
102
OSCILLATION GENERATION MEANS
SA
124
123
105
106
107
108

FIG. 23

FIG. 24B

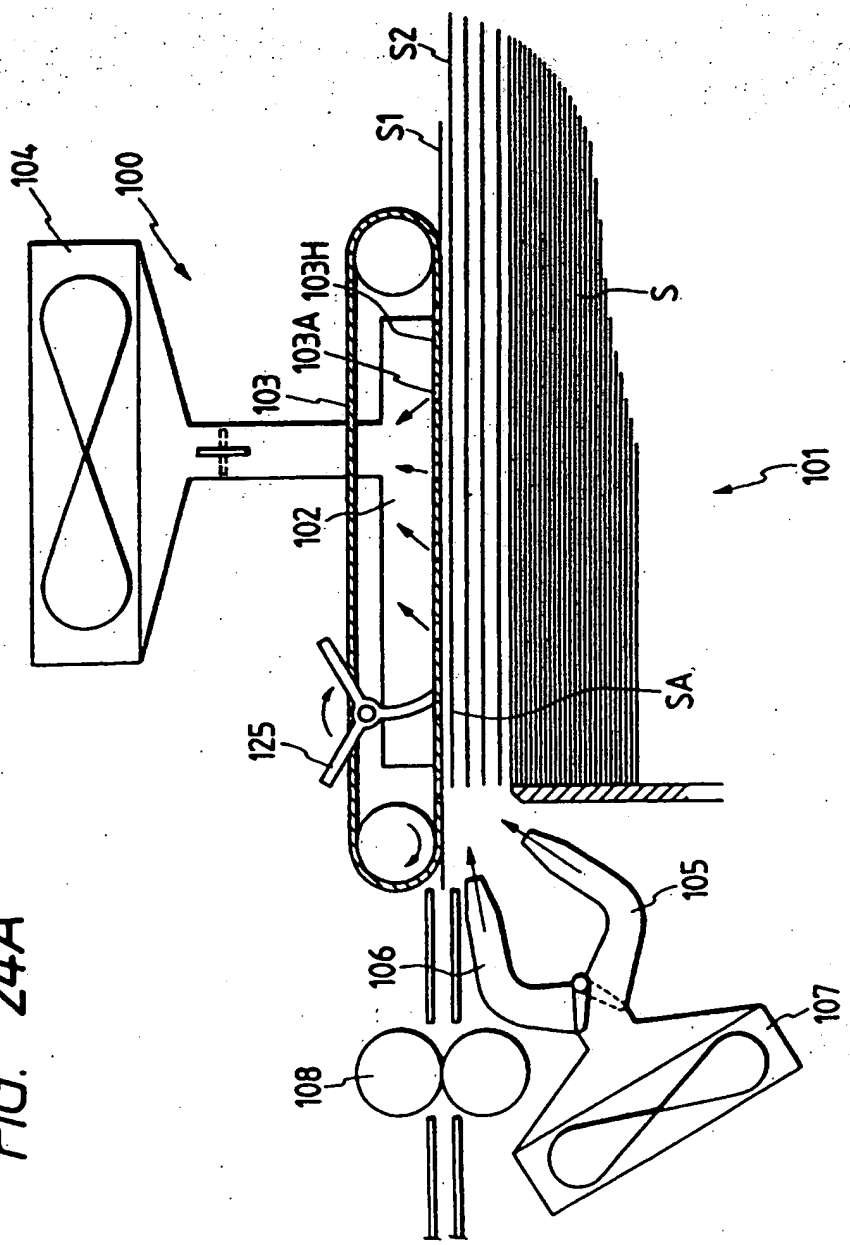


FIG. 24A

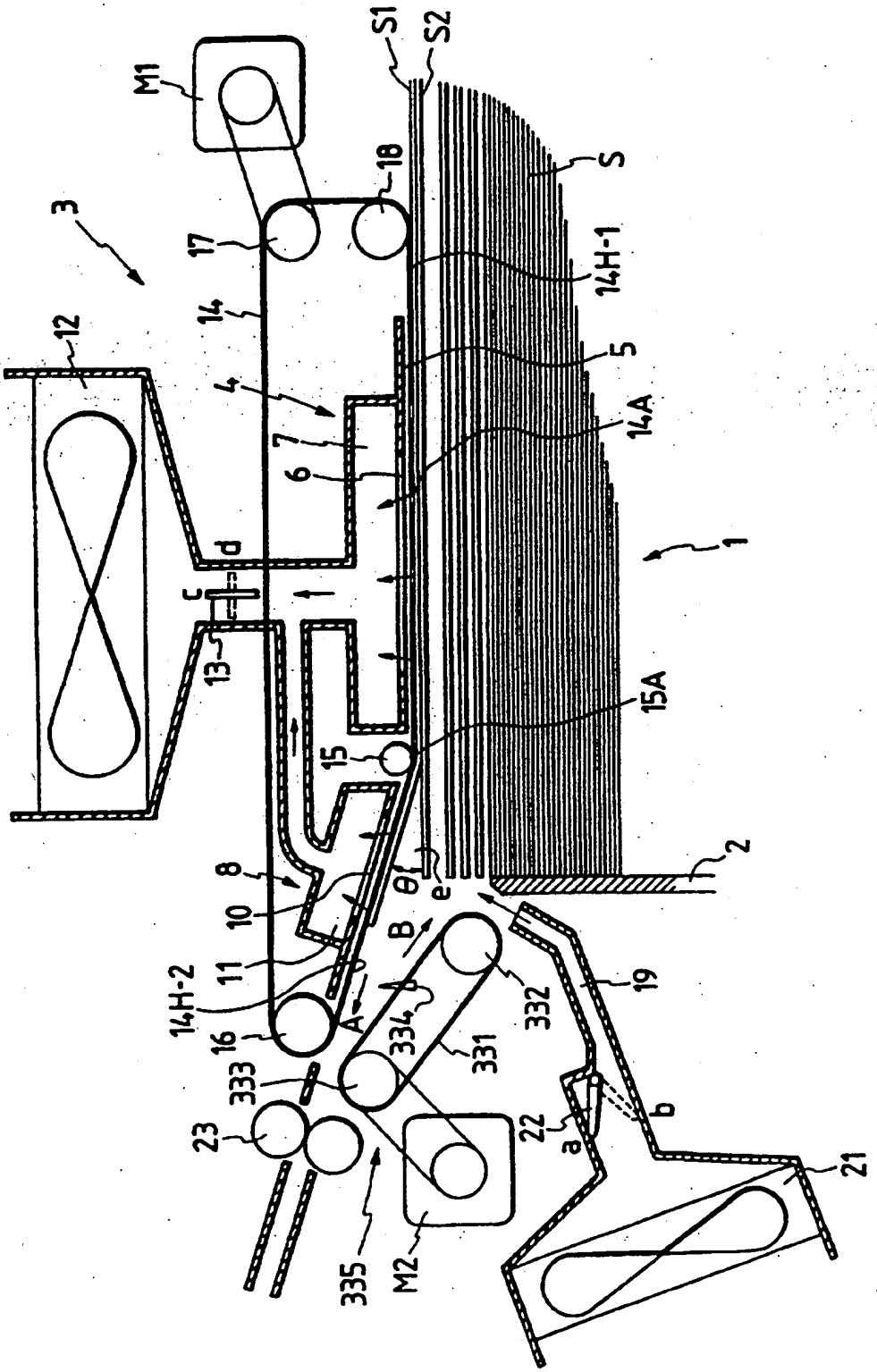

M1
S1
S2
S
18
17
3
14H-1
14
12
5
4
14A
7
6
1
d
c
13
15A
15
2
8
θ
e
10
B
11
14H-2
A
19
332
16
334
331
333
23
22
a
b
21
335
M2

FIG. 25

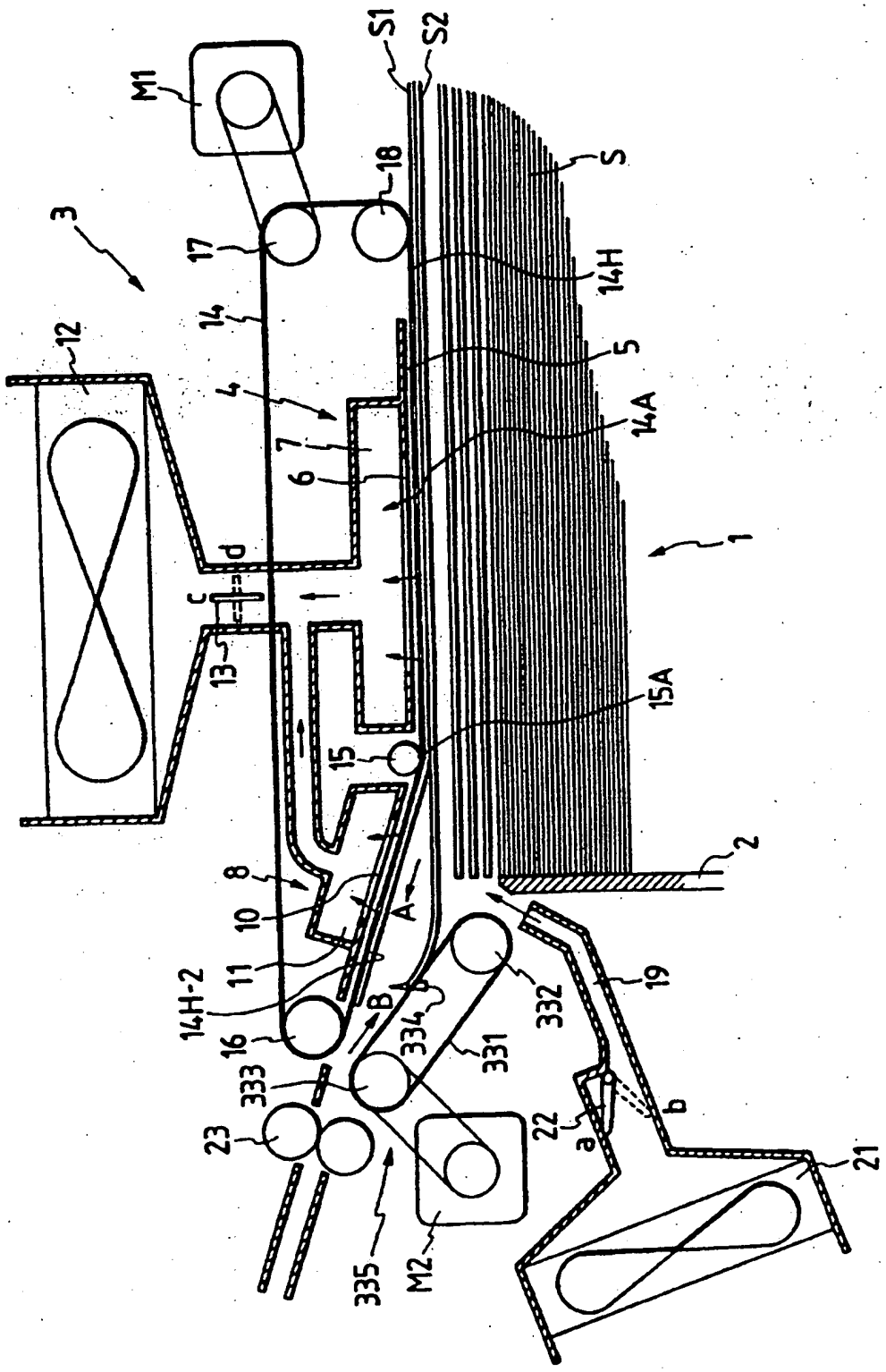

M1
S1
S2
S
18
3
17
14H
14
12
5
4
14A
7
6
1
d
c
13
15A
15
2
8
10
A
11
19
14H-2
B
332
16
334
331
333
23
22
a
b
21
335
M2

FIG. 26

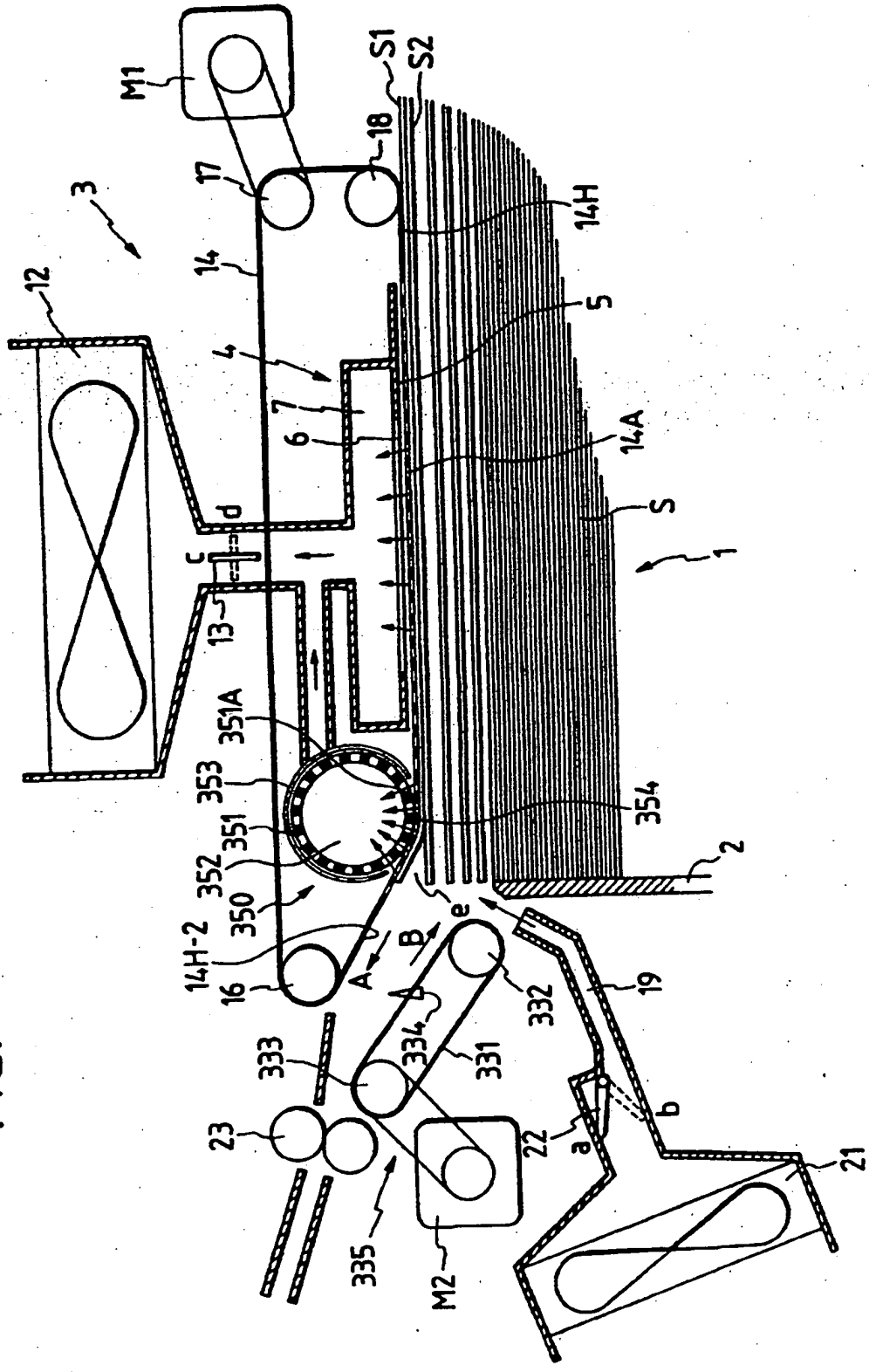

M1
S1
S2
18
17
3
14H
14
12
5
4
7
6
14A
S
d
c
1
13
351A
353
354
351
352
2
350
14H-2
e
16
A
B
19
332
333
334
331
23
22
a
b
21
335
M2

FIG. 27

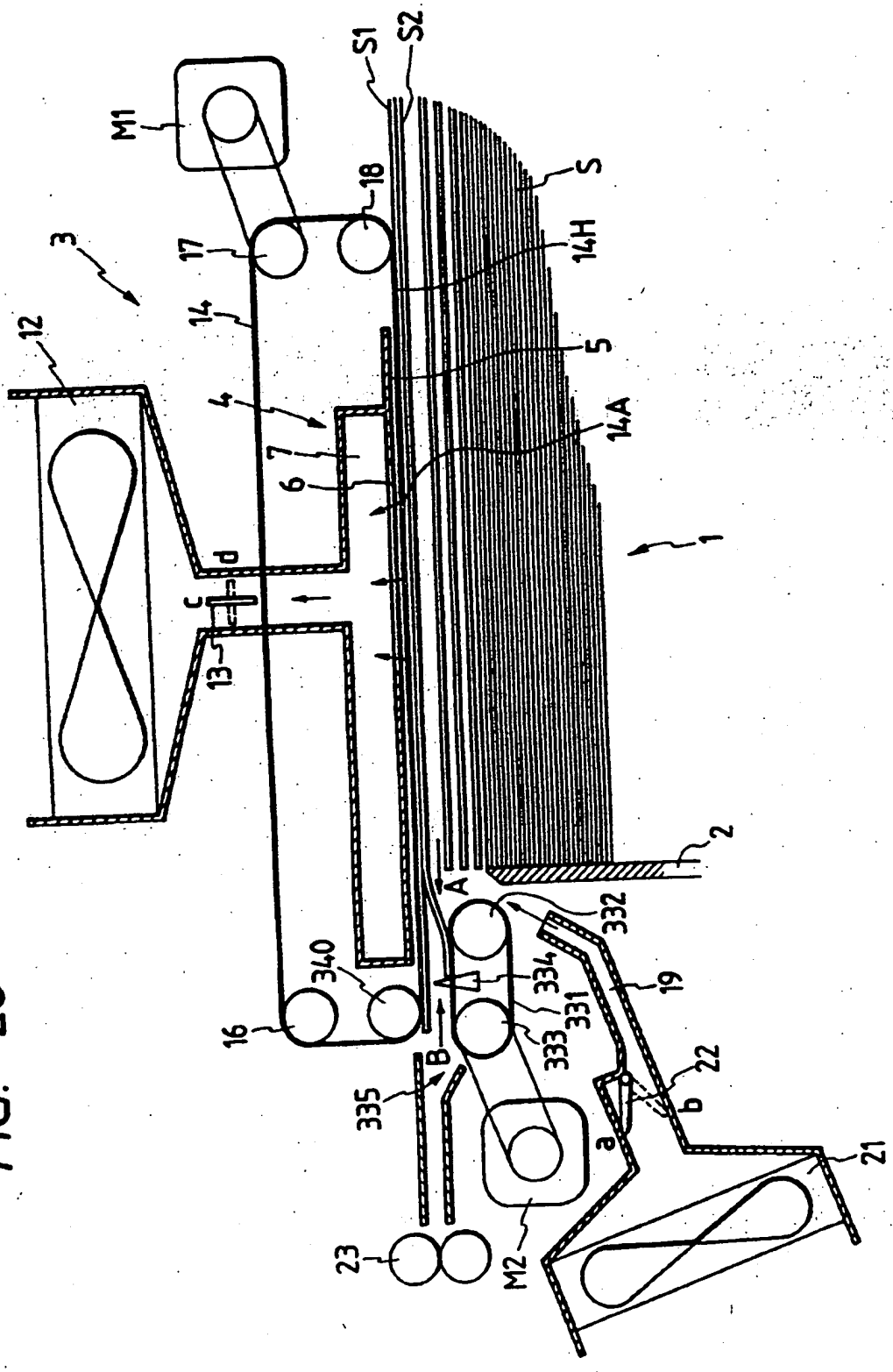

M1
S1
S2
S
18
17
14H
3
14
12
5
4
14A
7
6
1
d
c
13
2
A
332
340
334
19
16
331
333
B
22
335
b
a
21
23
M2

FIG. 28

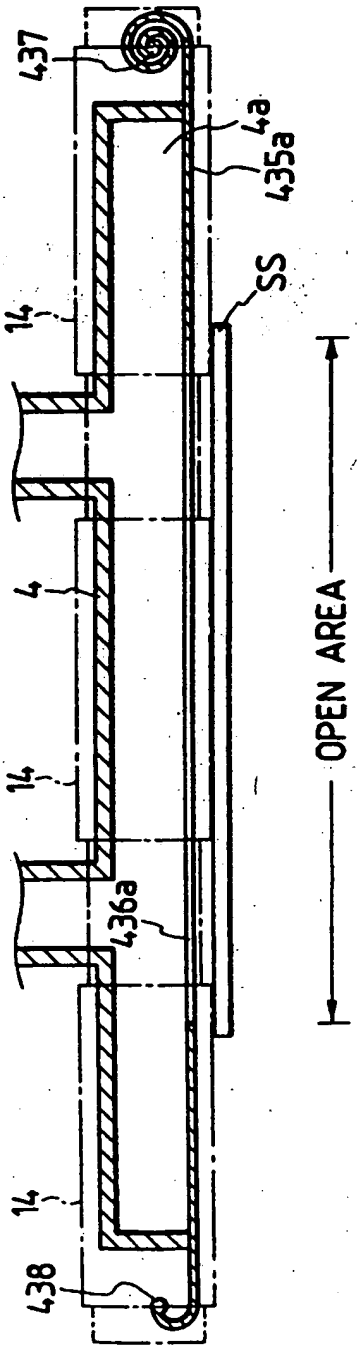


FIG. 29A

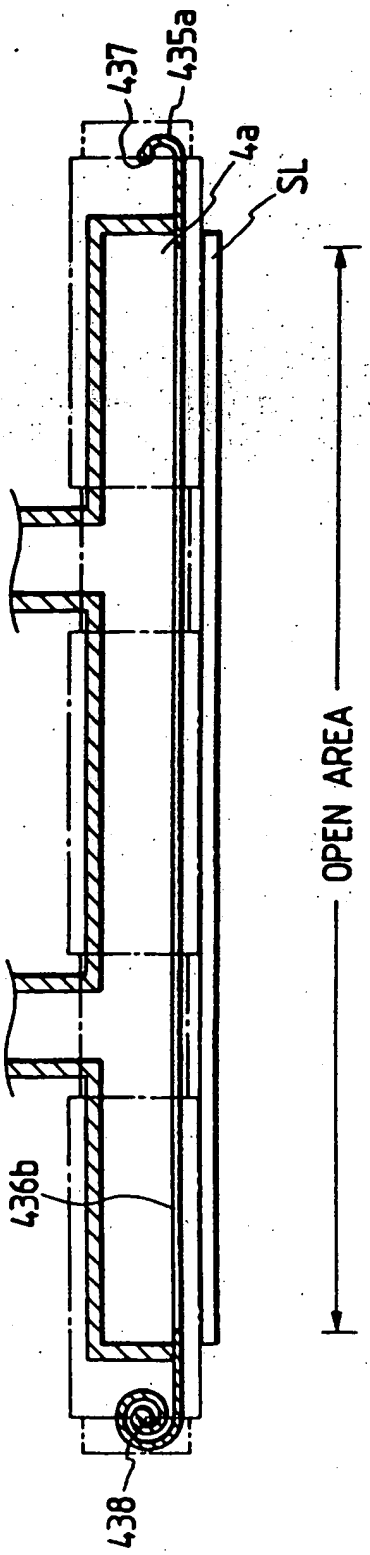


FIG. 29B

FIG. 30A

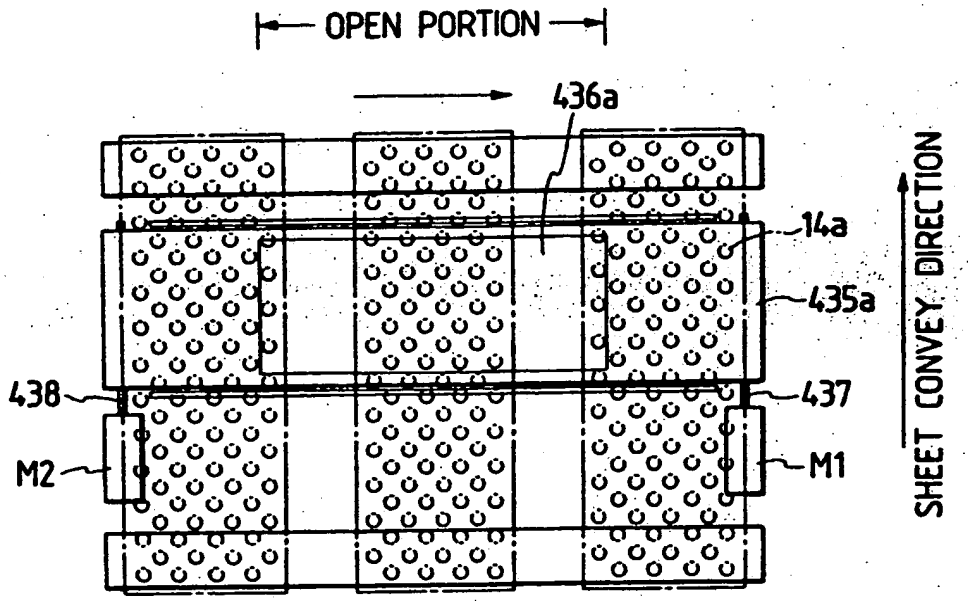


FIG. 30B

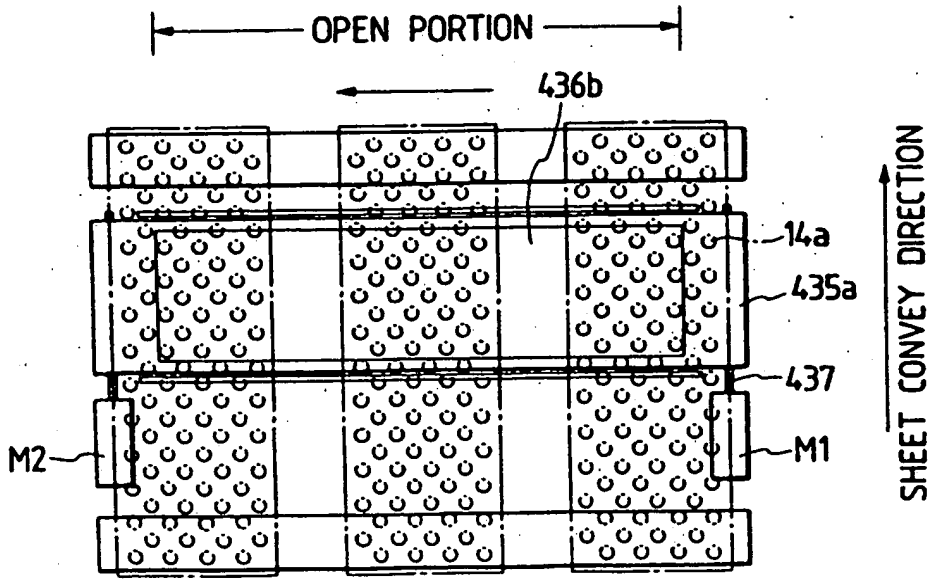


FIG. 31

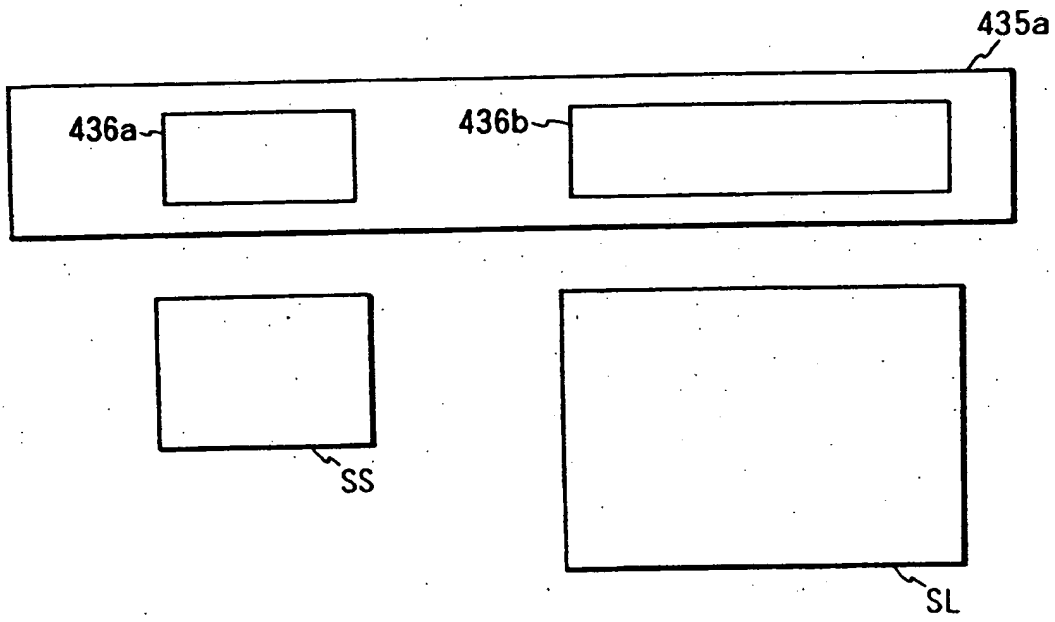


FIG. 32A

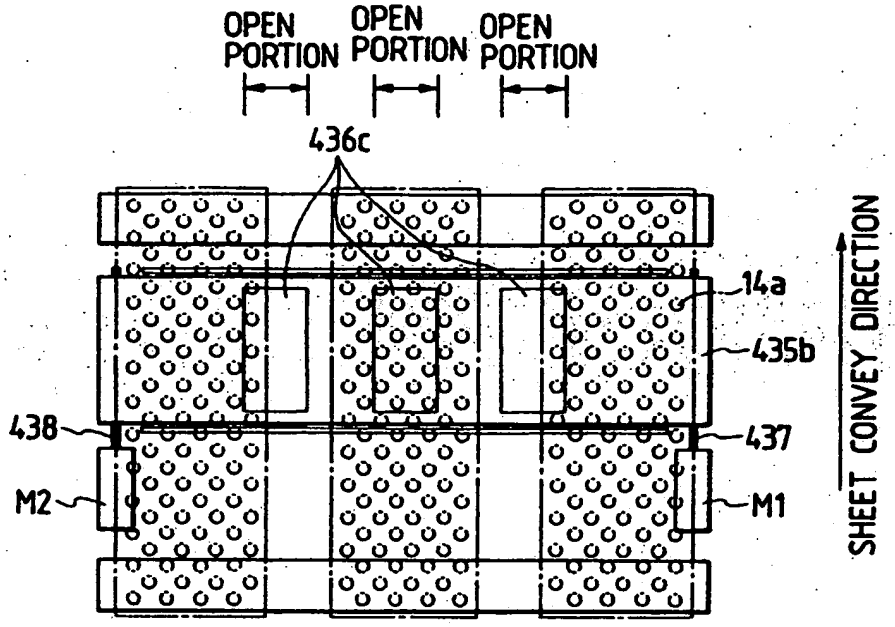


FIG. 32B

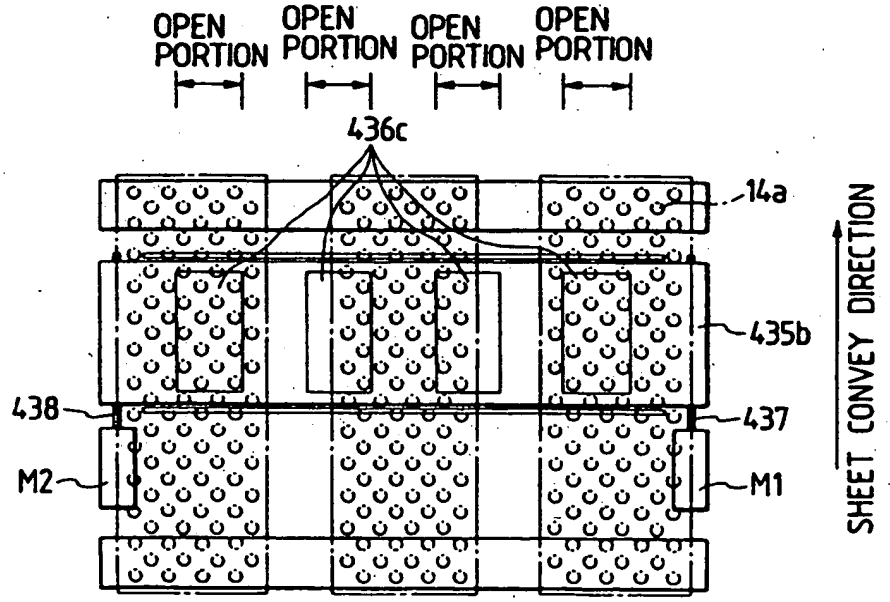


FIG. 33

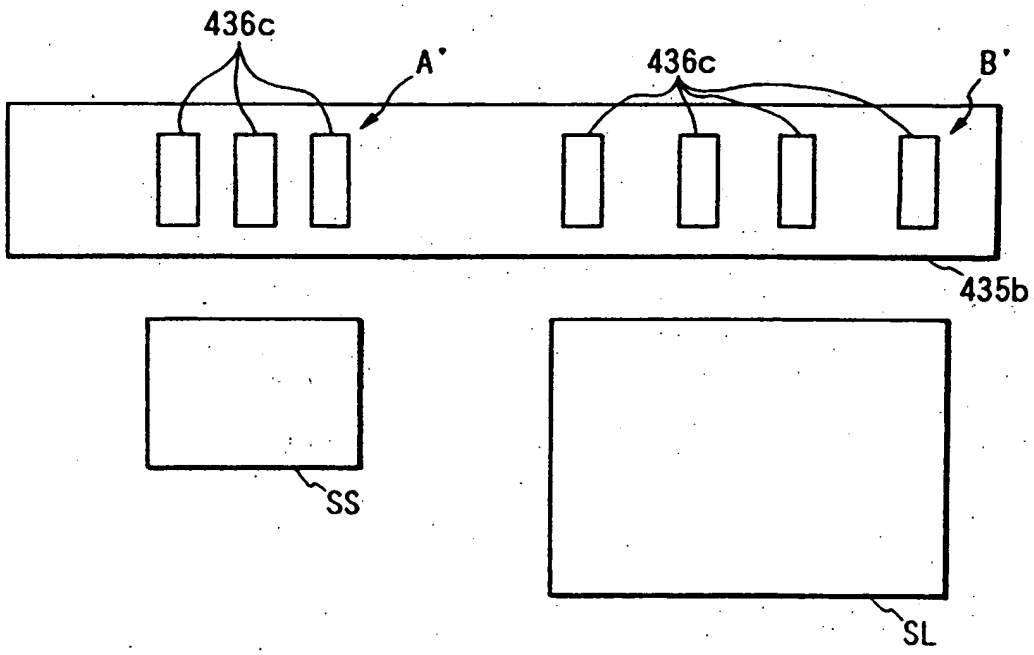


FIG. 34

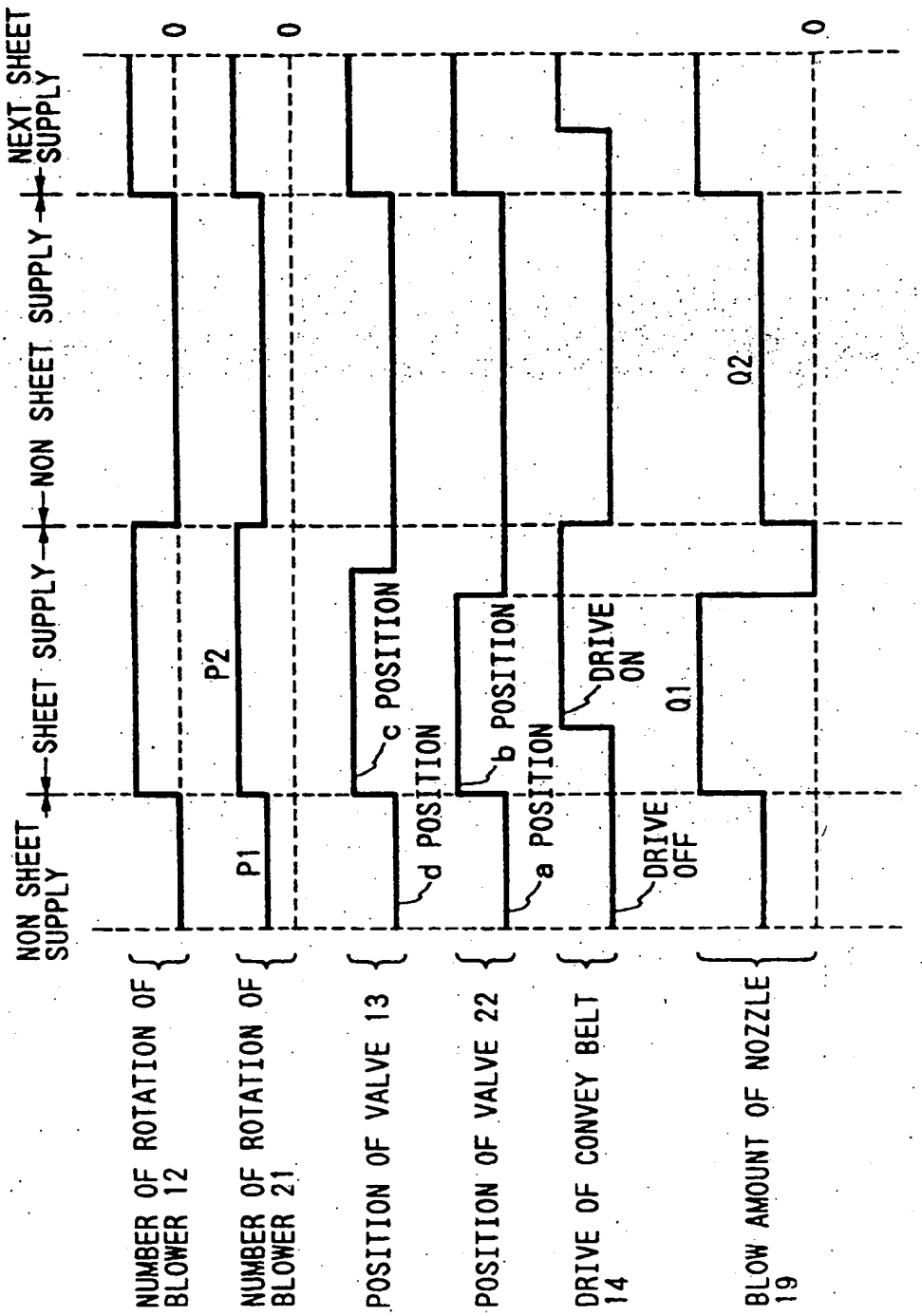

NON SHEET SUPPLY
SHEET SUPPLY
NON SHEET SUPPLY
NEXT SHEET SUPPLY
NUMBER OF ROTATION OF BLOWER 12
NUMBER OF ROTATION OF BLOWER 21
POSITION OF VALVE 13
POSITION OF VALVE 22
DRIVE OF CONVEY BELT 14
BLOW AMOUNT OF NOZZLE 19
P1
P2
d POSITION
c POSITION
a POSITION
b POSITION
DRIVE OFF
DRIVE ON
Q1
Q2
0
0
0

FIG. 35

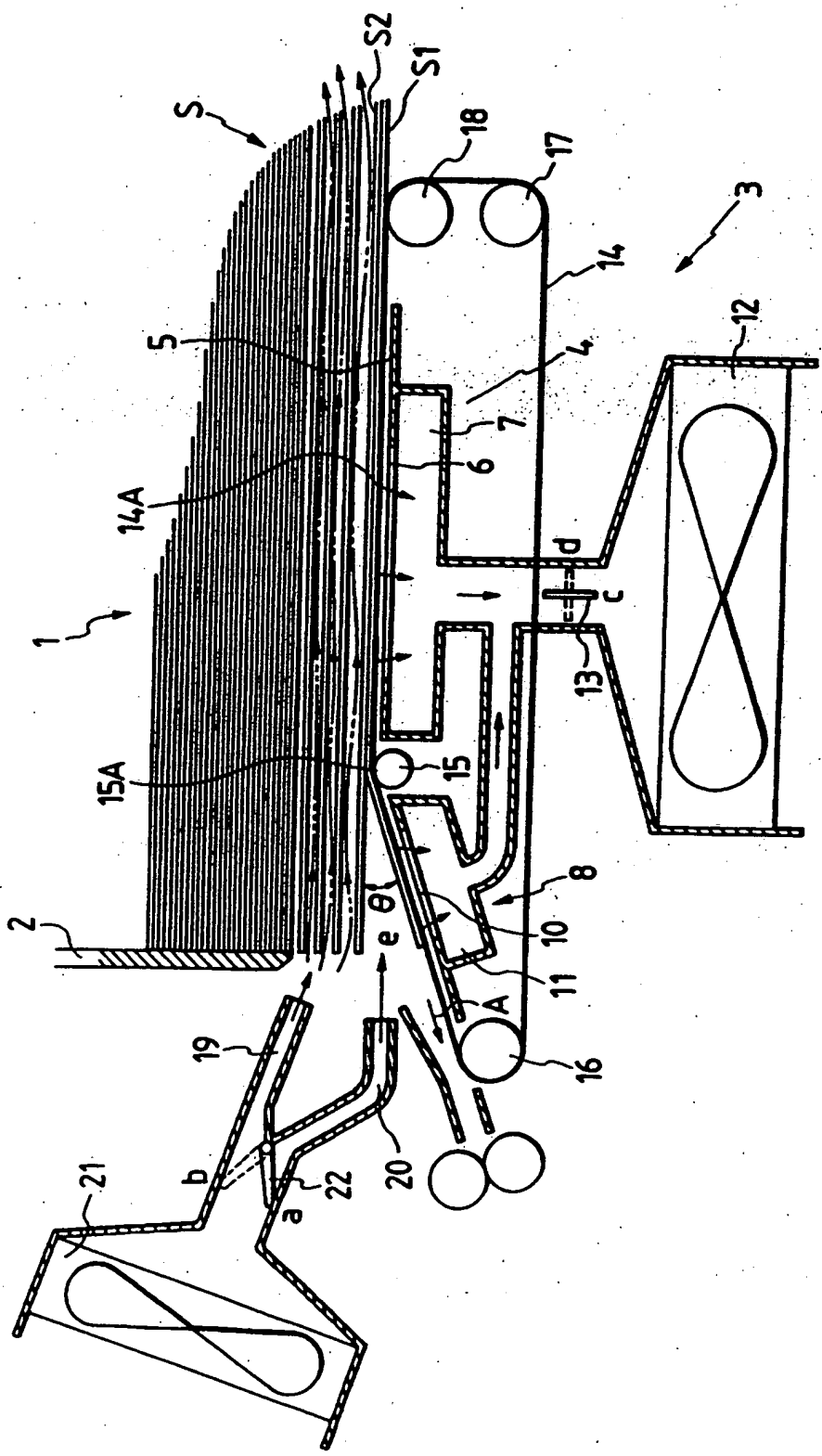

S2
S1
S
18
17
3
14
12
5
4
7
6
14A
d
c
1
13
15A
15
8
2
e
θ
10
11
A
19
16
b
21
22
20
a

FIG. 36C

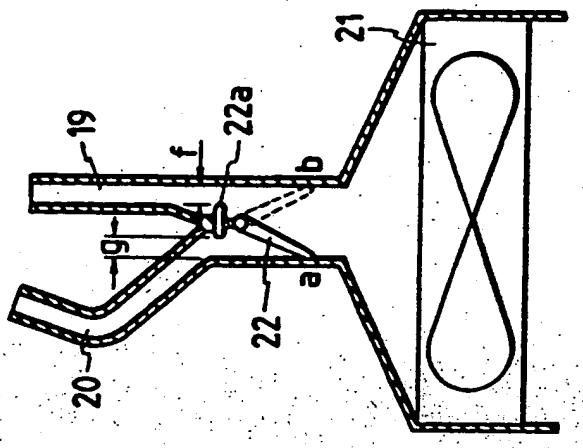


FIG. 36B

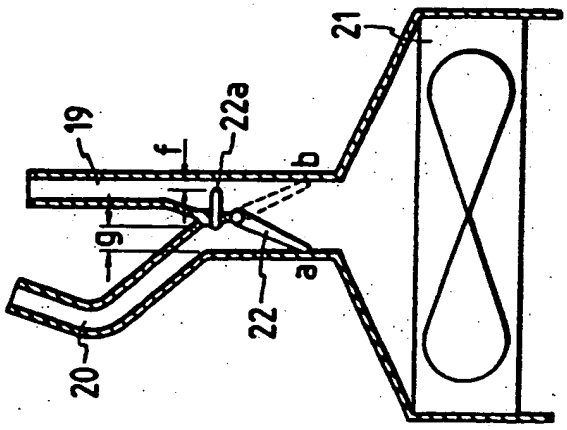


FIG. 36A

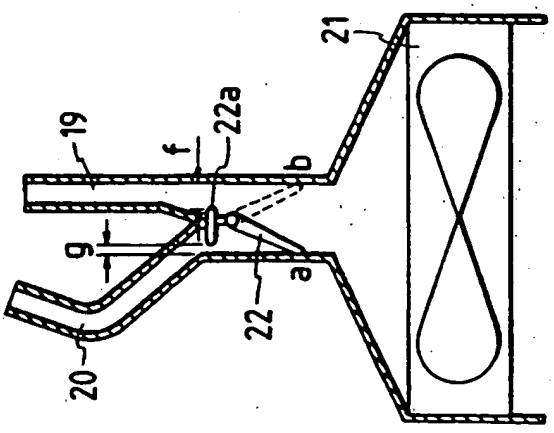
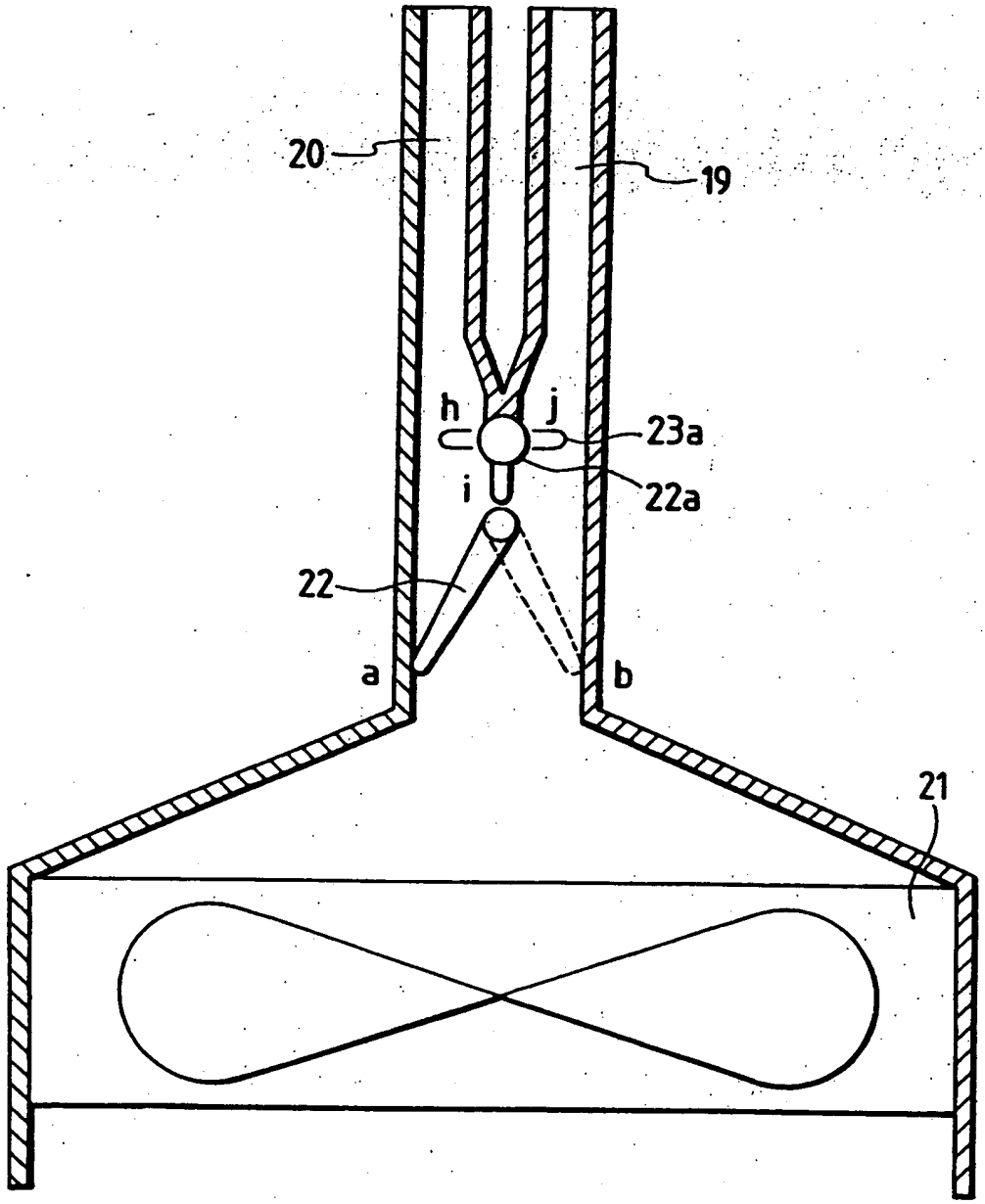


FIG. 37



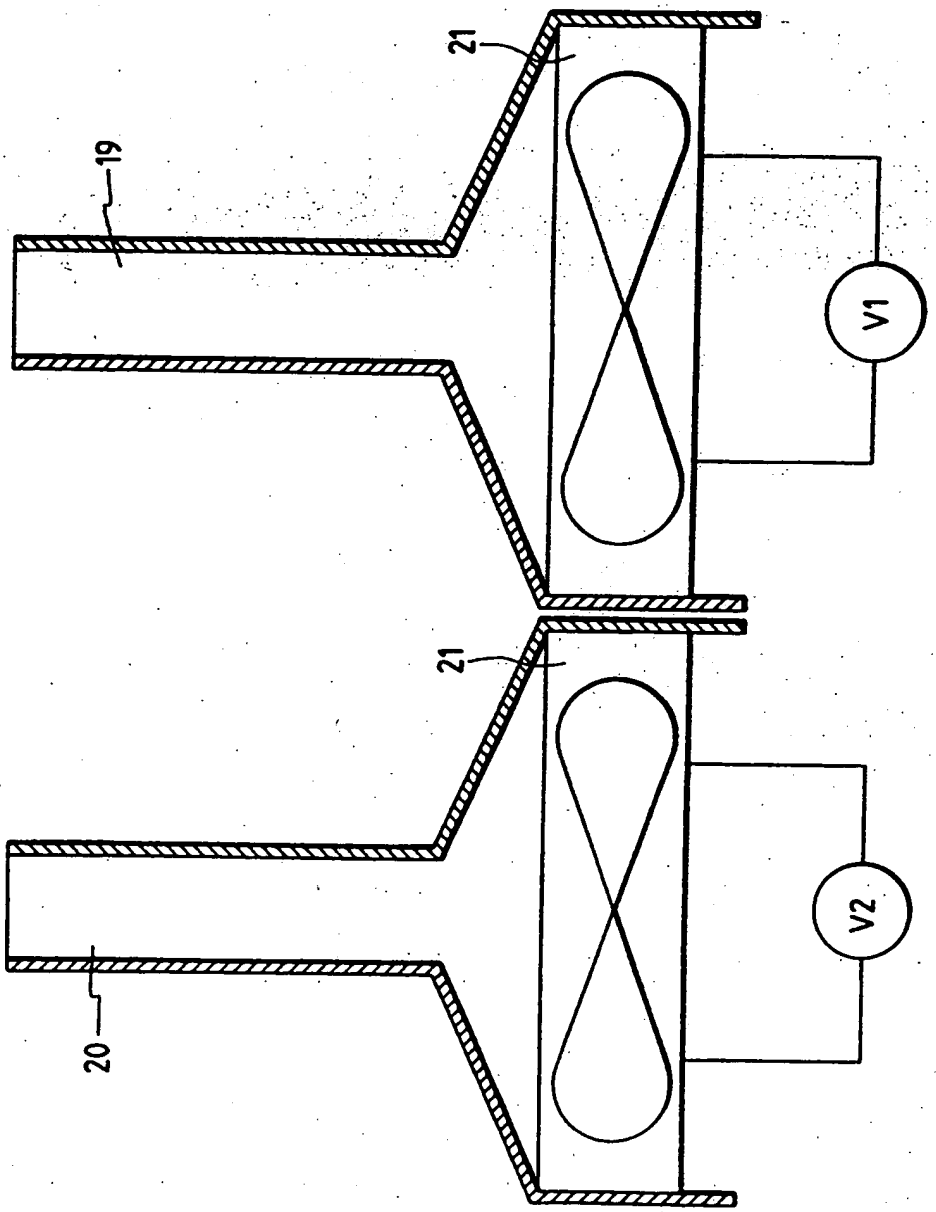


FIG. 38

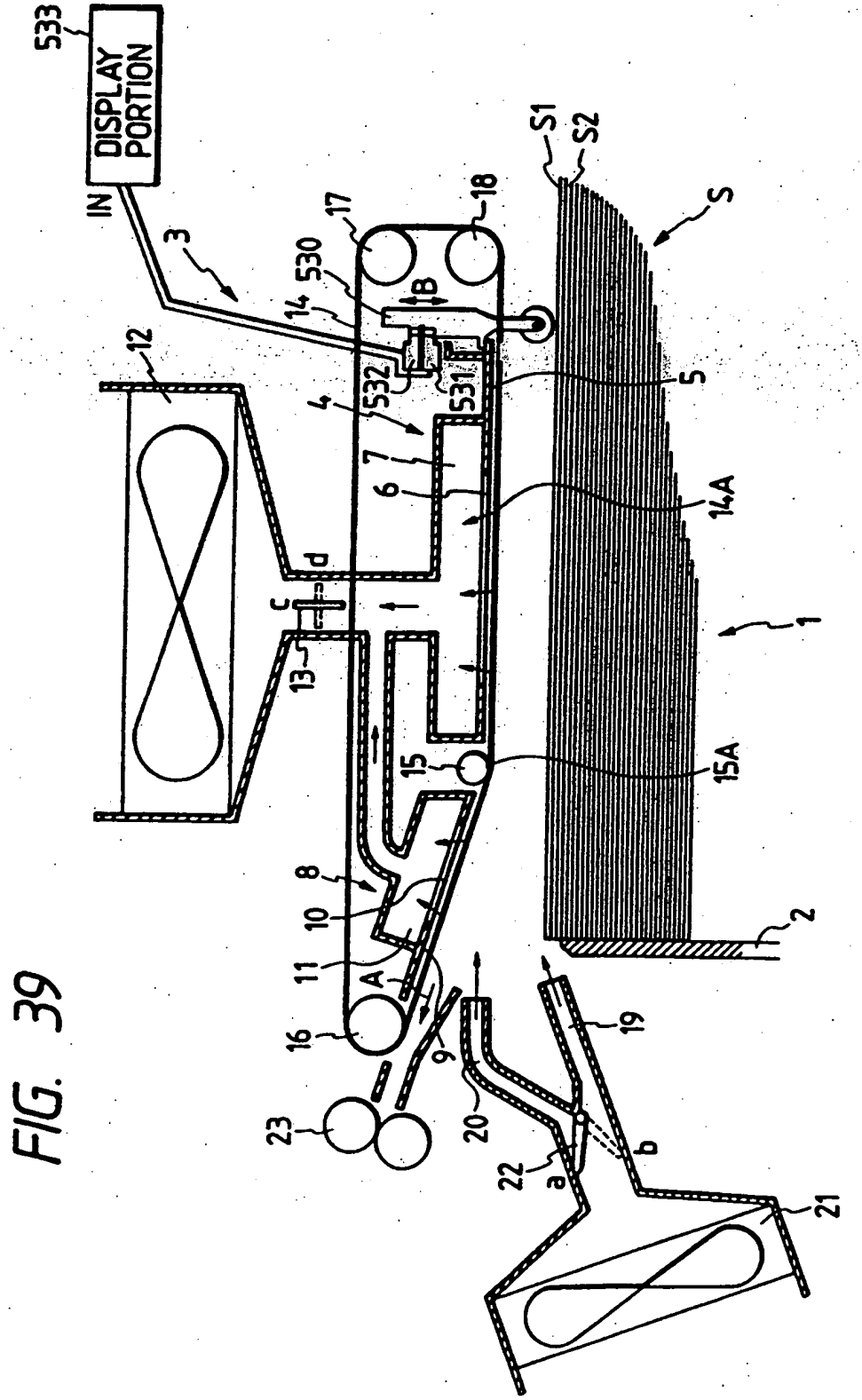

533
DISPLAY PORTION
IN
3
S1
S2
S
17
18
530
14
B
12
532
531
5
4
7
6
14A
d
C
13
1
15
15A
8
10
11
A
16
9
2
19
23
20
22
a
b
21

FIG. 39

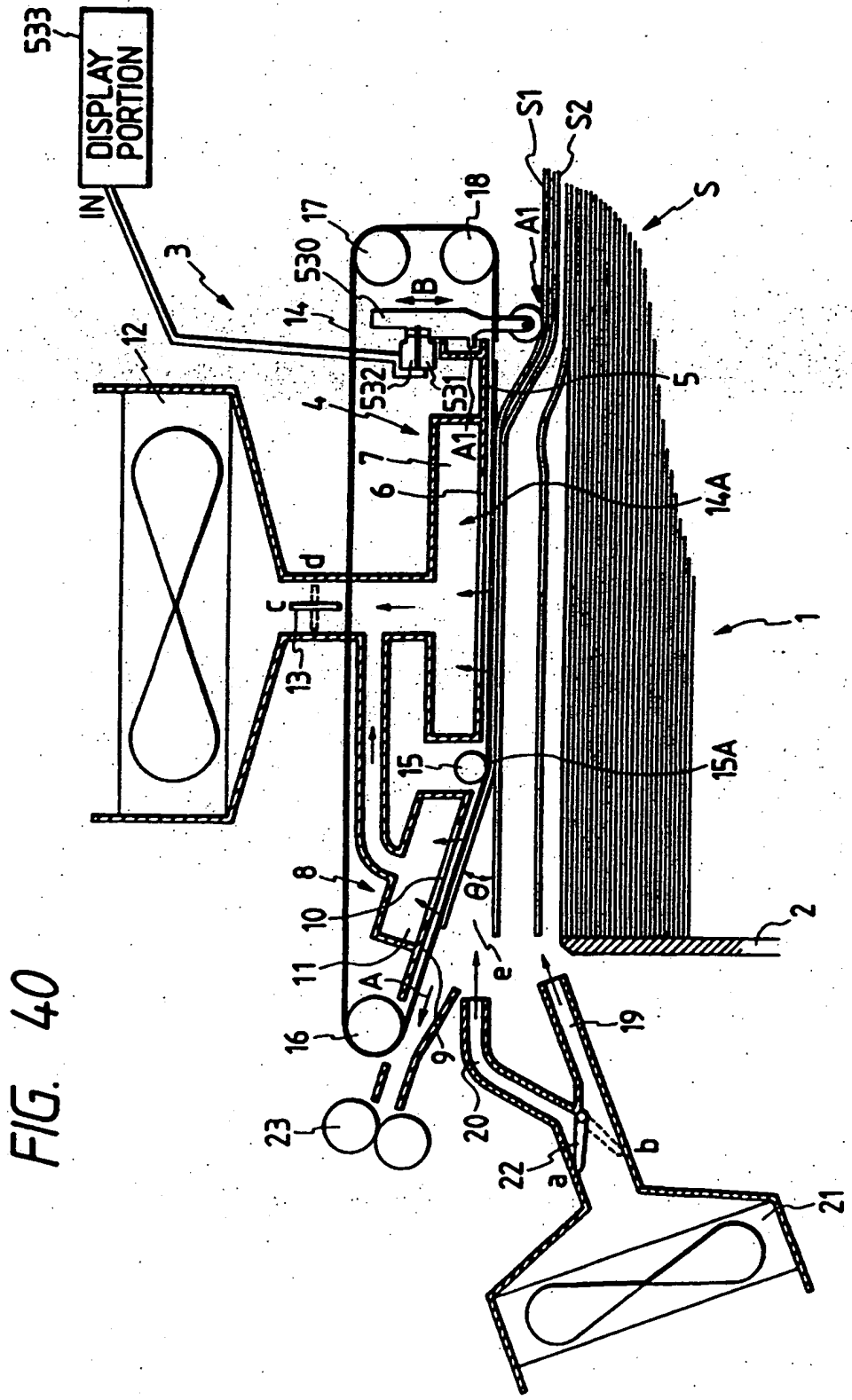

533
DISPLAY PORTION
IN
3
530
17
18
S1
S2
S
A1
B
14
12
532
531
5
4
7
6
A1
14A
d
C
13
1
15
15A
8
10
11
A
16
9
θ
e
2
19
20
22
a
b
23
21

FIG. 40

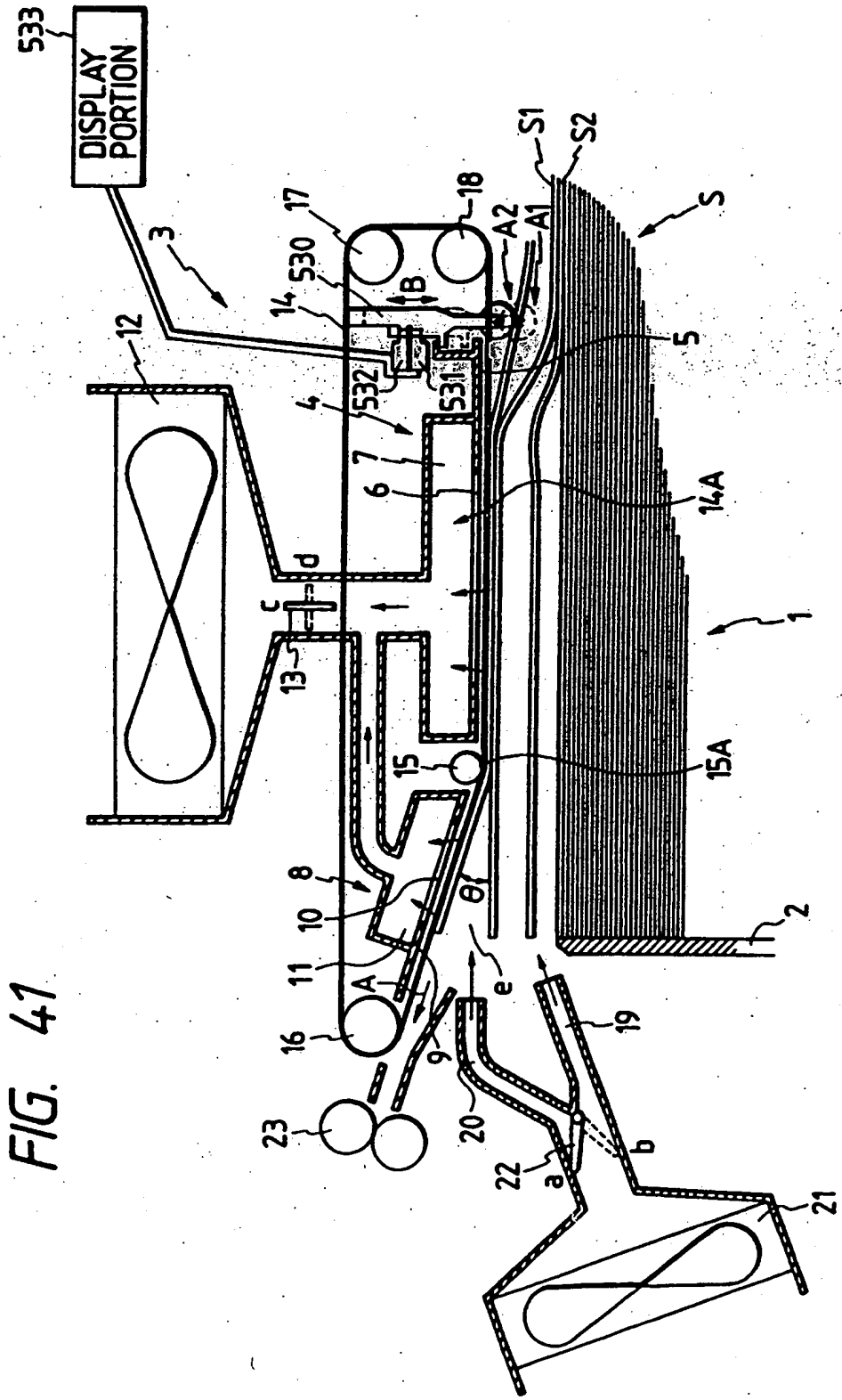

533
DISPLAY PORTION
3
12
17
18
530
14
B
S1
S2
A2
A1
S
5
532
531
4
7
6
14A
d
c
13
1
15
15A
8
10
11
A
16
9
θ
e
2
19
20
23
22
a
b
21

FIG. 41

FIG. 42

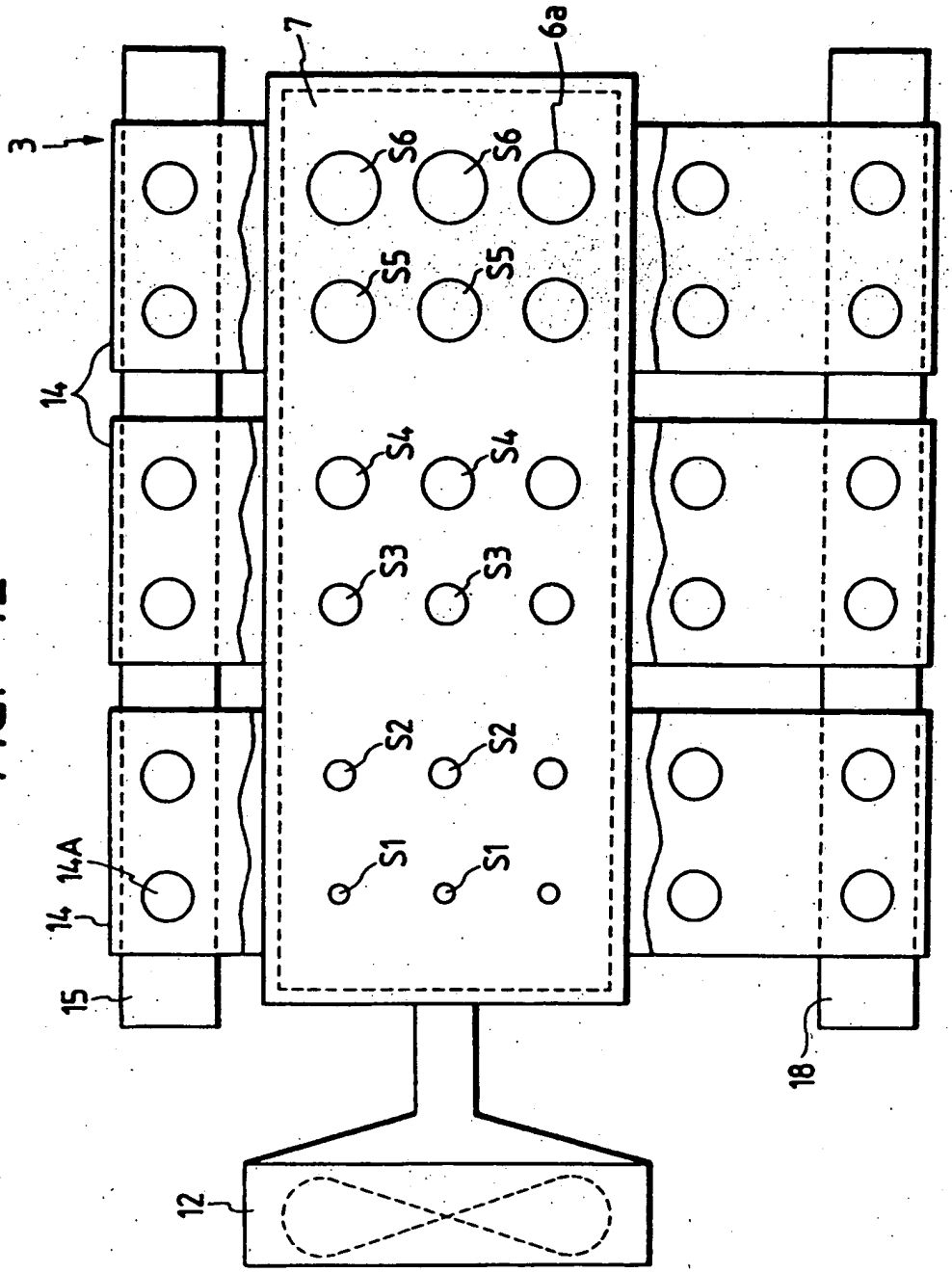
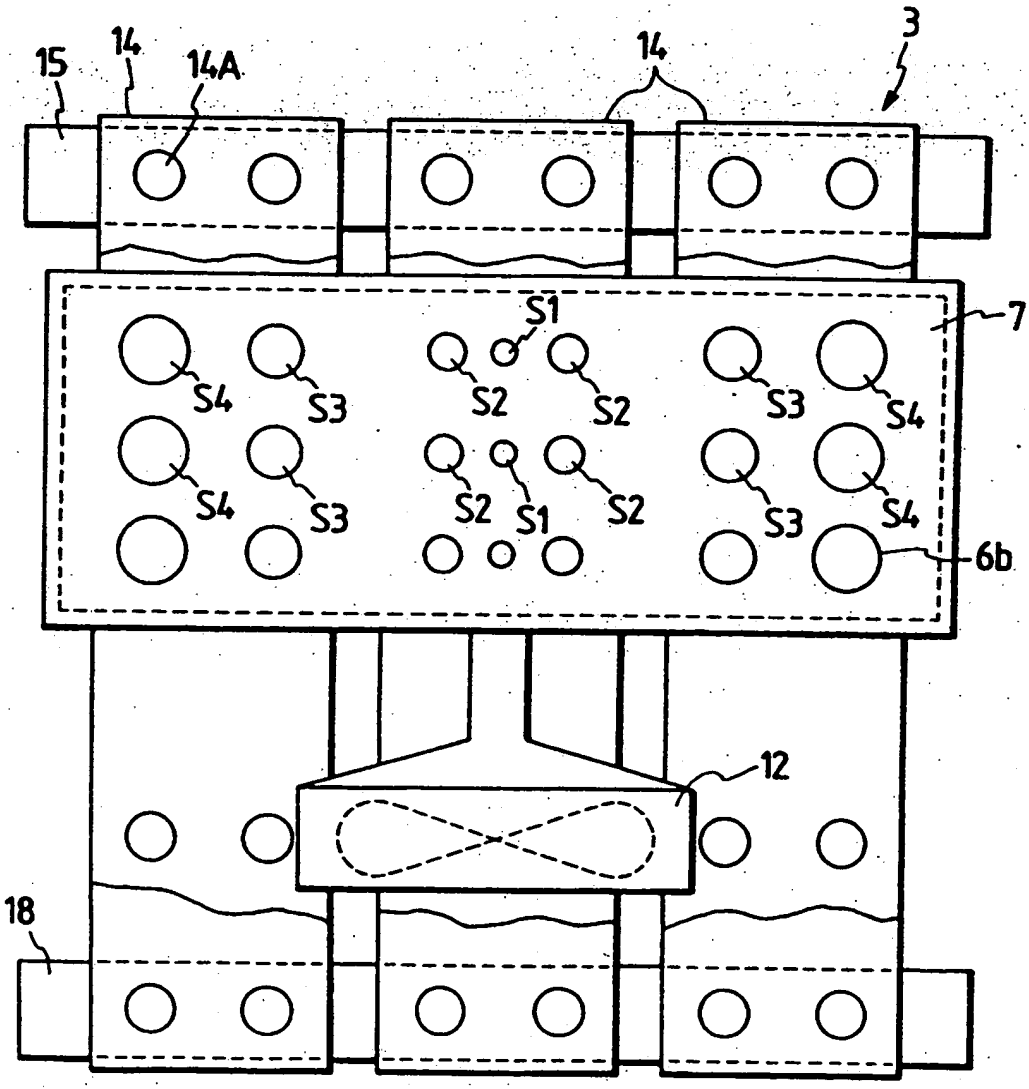


FIG. 43



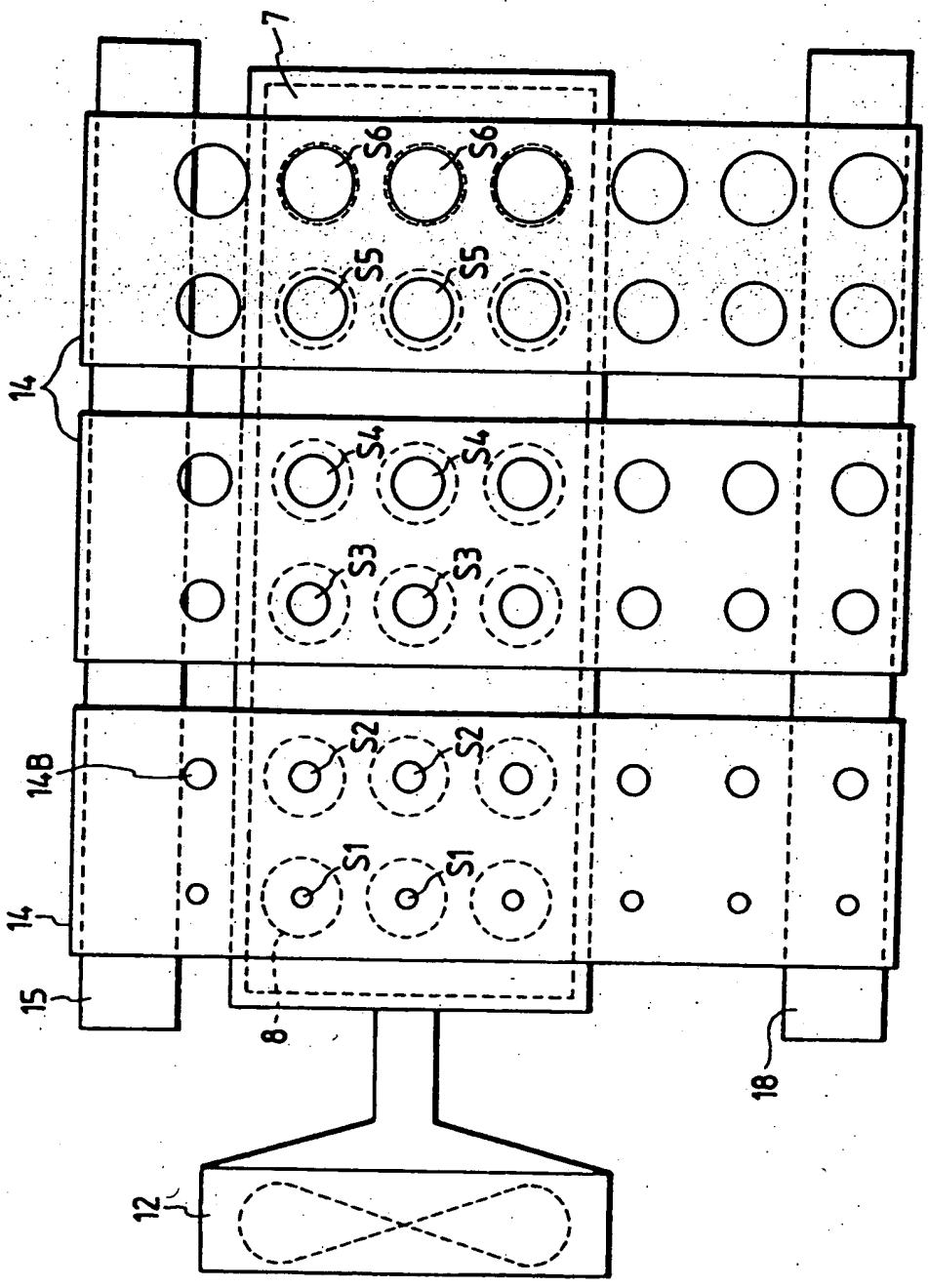


FIG. 44

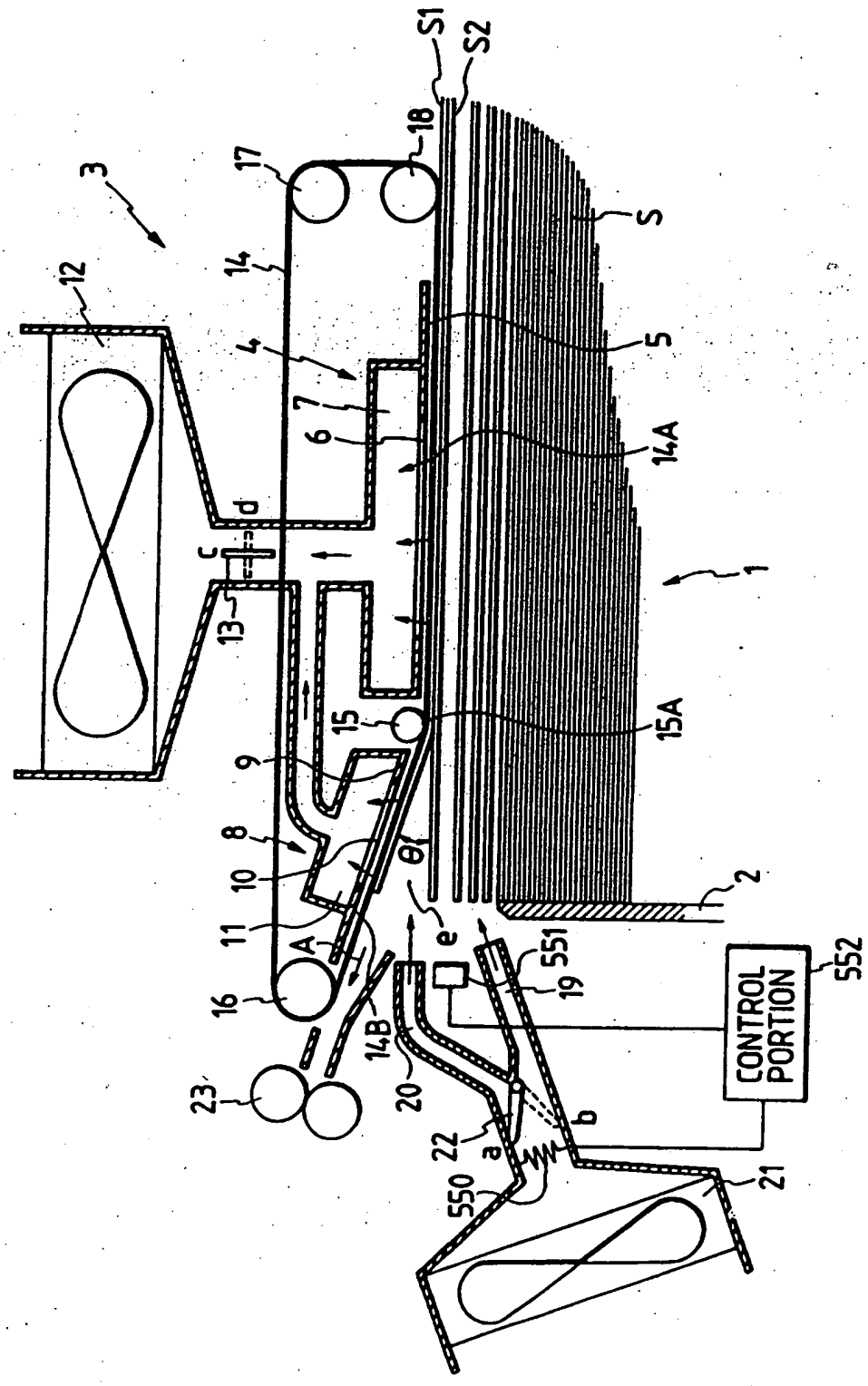

S1
S2
18
17
3
S
14
12
5
4
7
6
14A
d
c
13
1
15
15A
9
8
10
θ1
2
11
A
e
551
552
16
19
CONTROL PORTION
14B
23
20
22
b
a
21
550

FIG. 45

FIG. 46

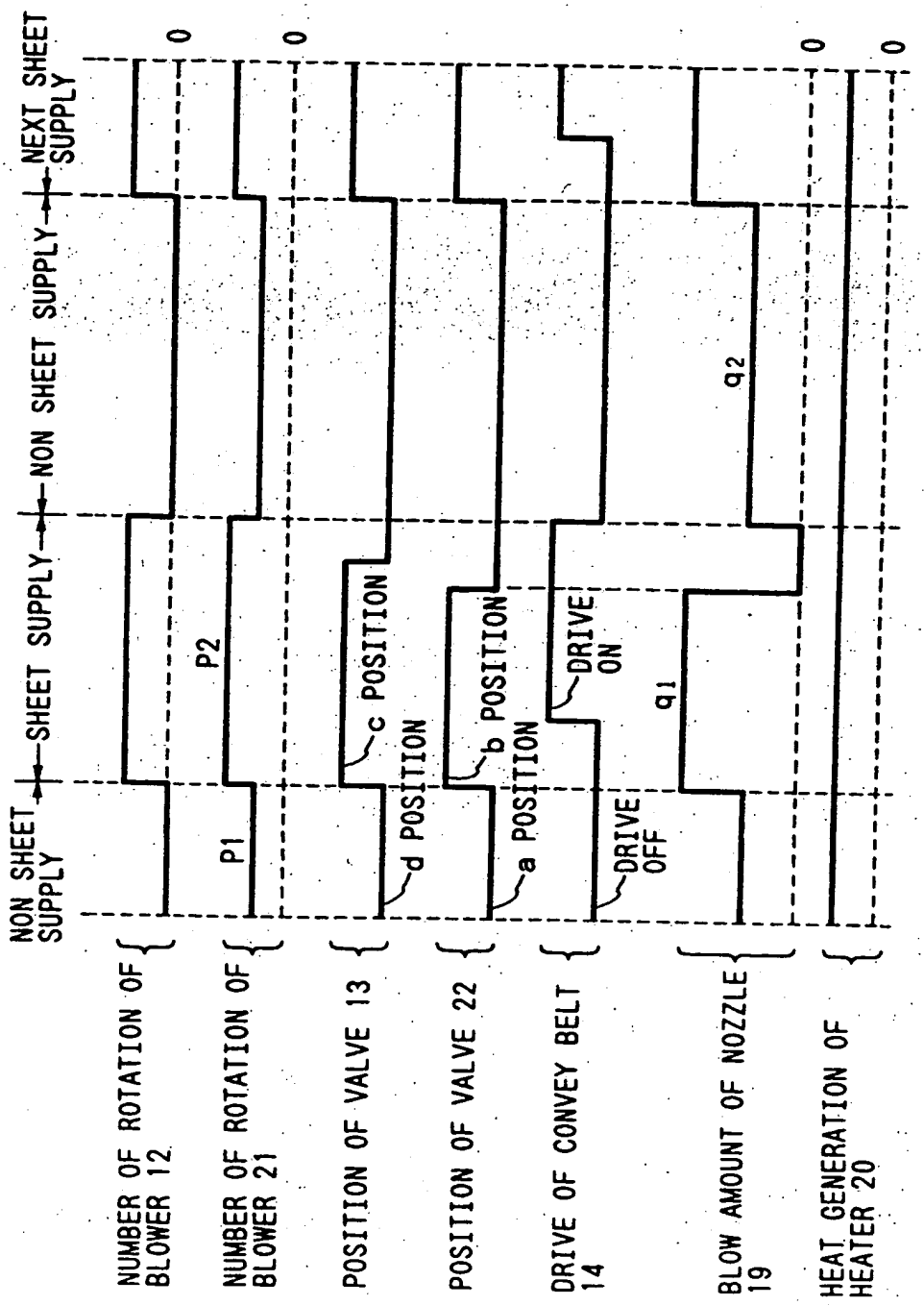

NON SHEET SUPPLY
SHEET SUPPLY
NON SHEET SUPPLY
NEXT SHEET SUPPLY
0
0
0
0
P1
P2
d POSITION
c POSITION
a POSITION
b POSITION
DRIVE OFF
DRIVE ON
q1
q2
NUMBER OF ROTATION OF BLOWER 12
NUMBER OF ROTATION OF BLOWER 21
POSITION OF VALVE 13
POSITION OF VALVE 22
DRIVE OF CONVEY BELT 14
BLOW AMOUNT OF NOZZLE 19
HEAT GENERATION OF HEATER 20

FIG. 47

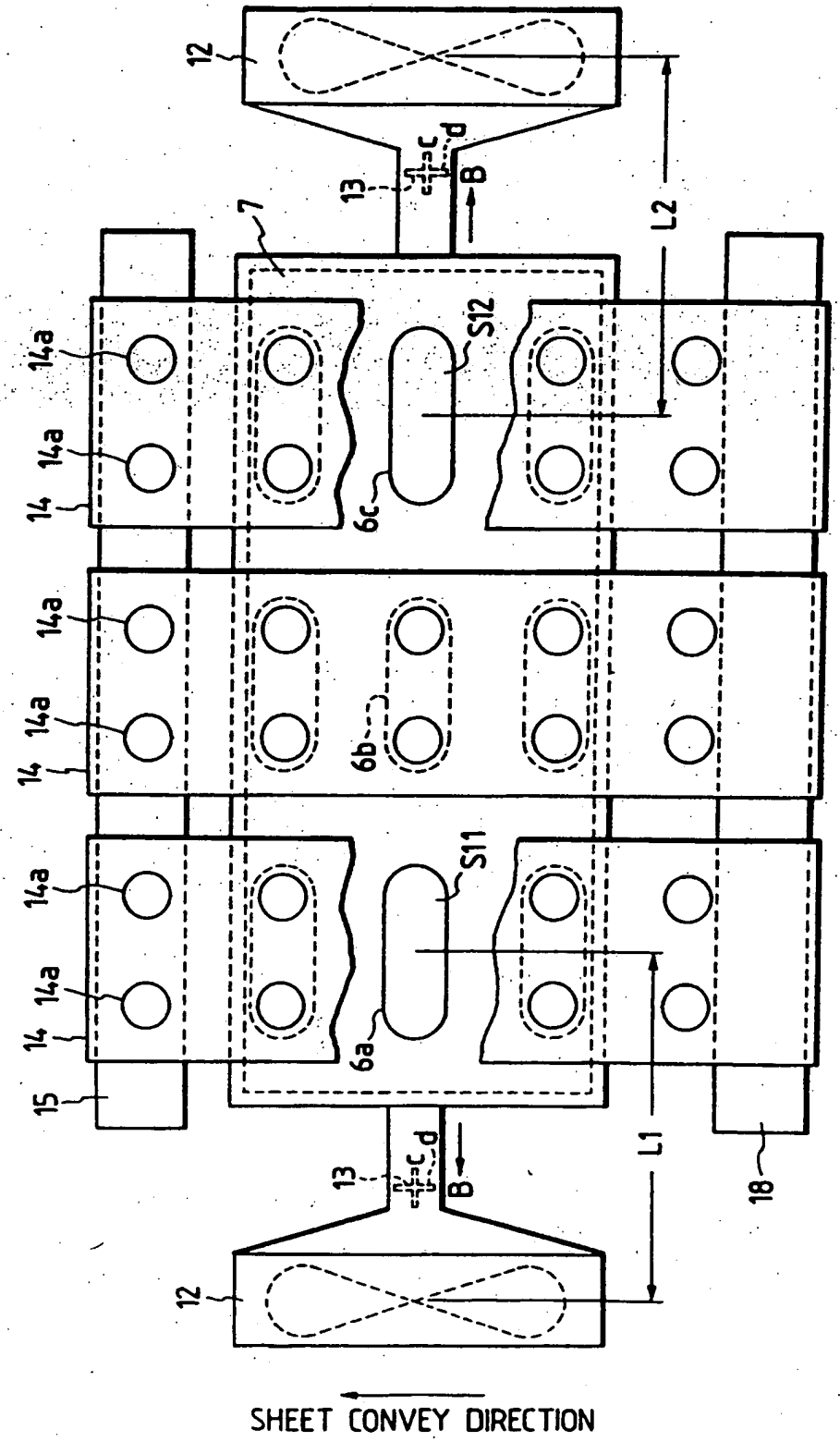
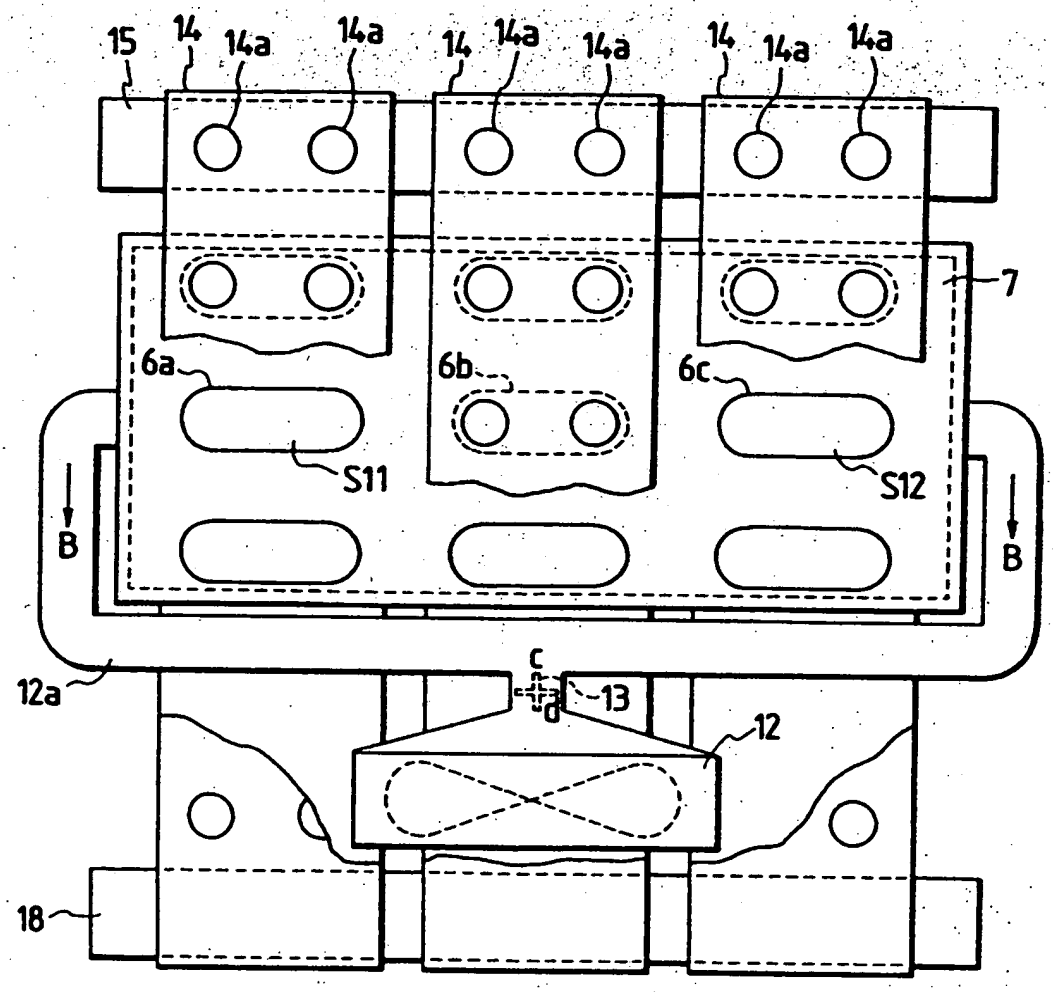

12
13
B
d
c
7
L2
S12
14a
14
6c
6b
S11
6a
15
L1
18
SHEET CONVEY DIRECTION

FIG. 48


15
14
14a
14a
14
14a
14a
14
14a
14a
7
6a
6b
6c
S11
S12
B
B
12a
C
d
13
12
18

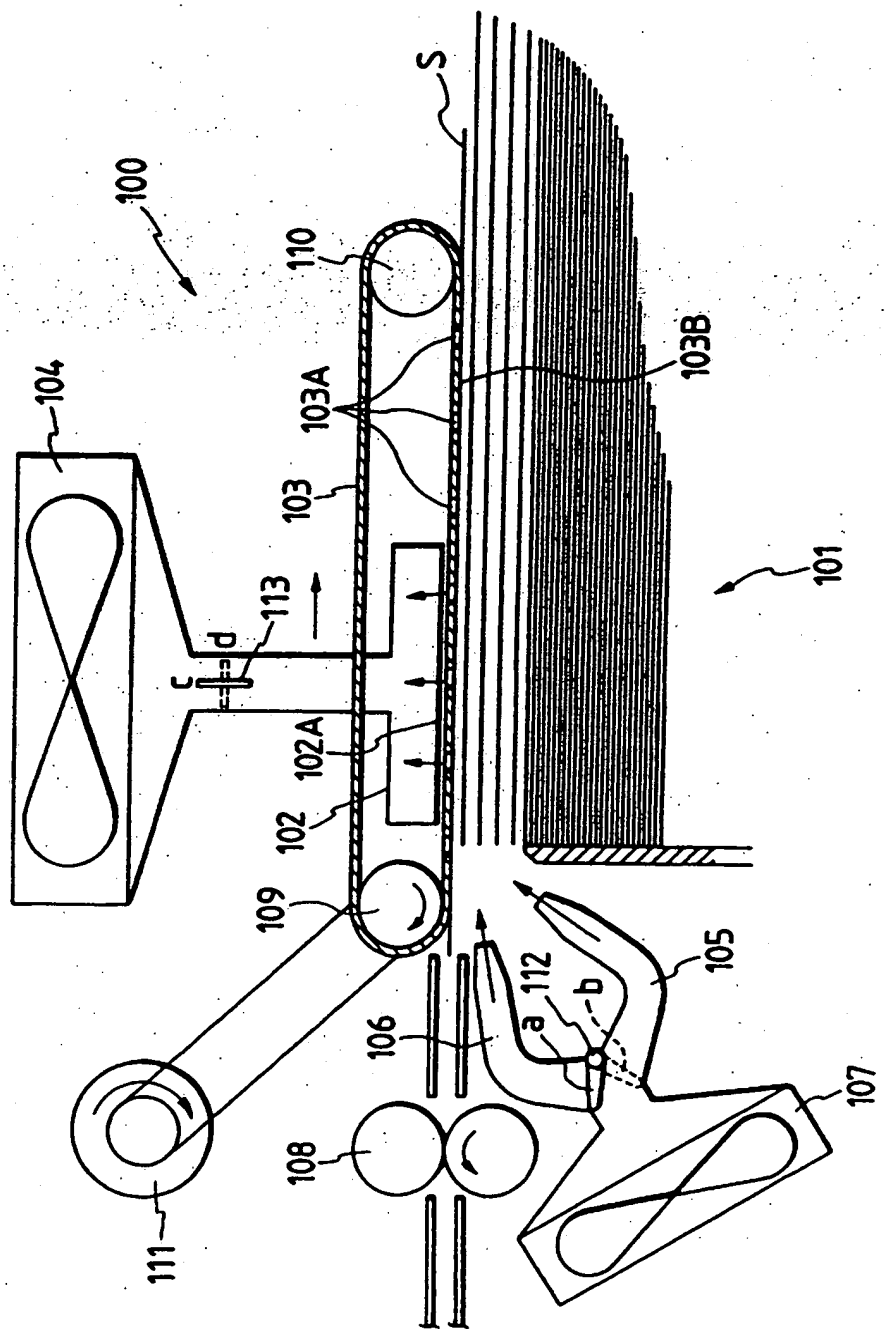


FIG. 49
PRIOR ART

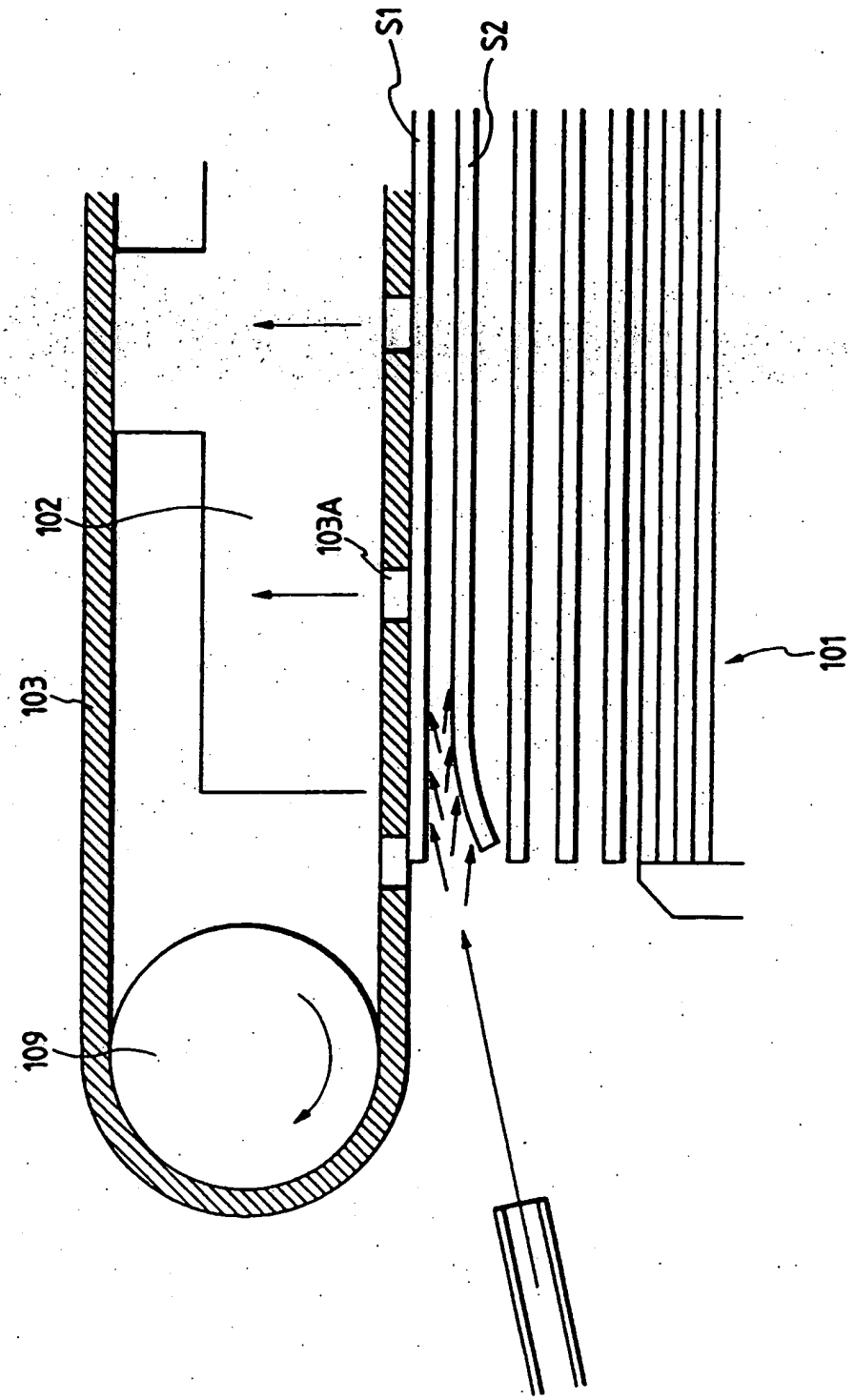


FIG. 50
PRIOR ART

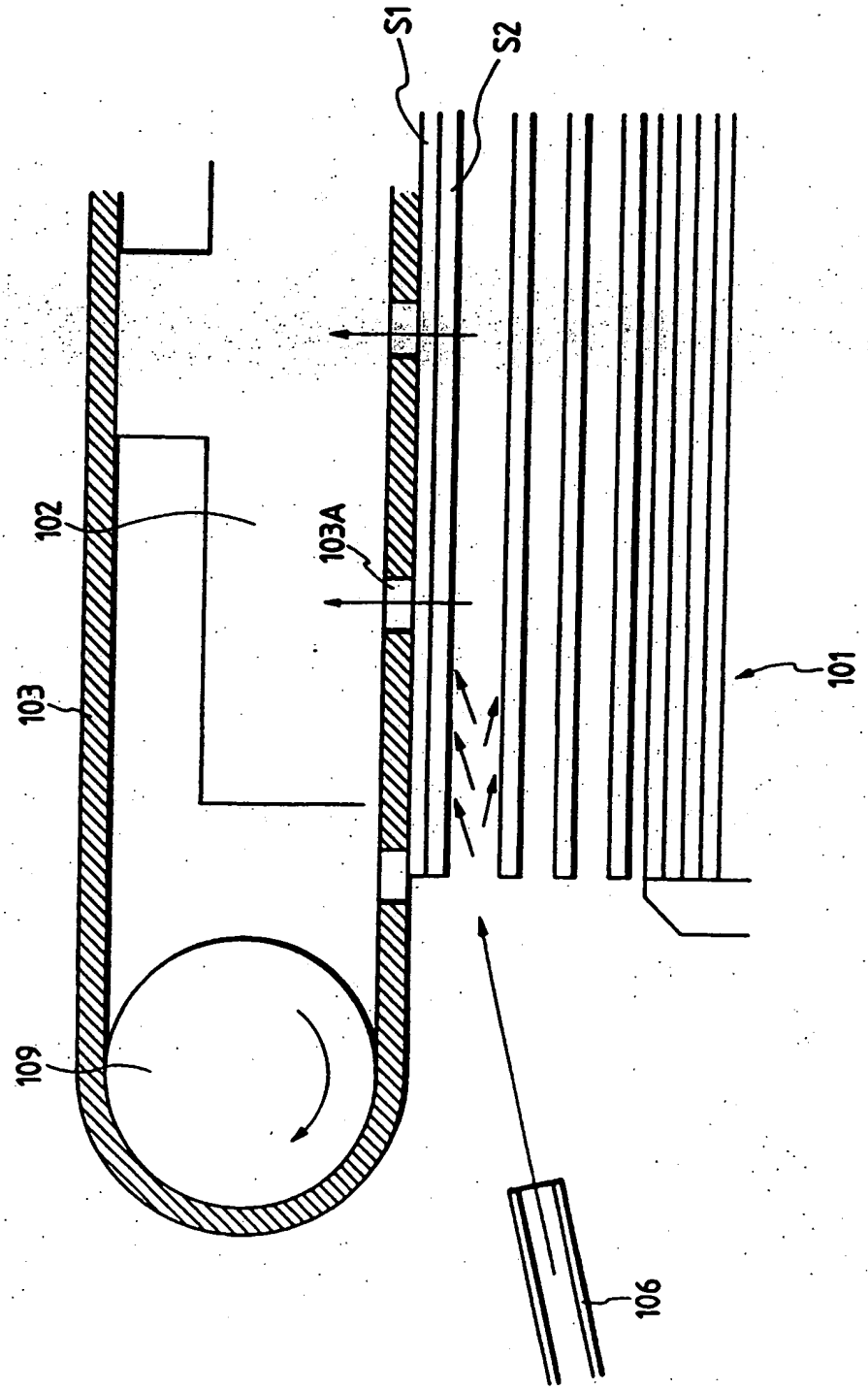


FIG. 51
PRIOR ART

SHEET SUPPLY APPARATUS

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to a sheet supply apparatus used with an image forming apparatus such as a copying machine, a printer, a facsimile machine and the like.

2. Related Background Art

In the past, generally, in sheet supply apparatuses used with an image forming apparatus such as a copying machine, a printer, a facsimile machine and the like, sheets stacked on a sheet stacking tray were conveyed one by one by rotational friction of a sheet supply roller. In the sheet supply apparatus of this kind, a surface of the sheet supply roller is formed from elastic material such as rubber, so that the sheet supplying ability greatly depends upon the coefficient of friction of the roller surface. Accordingly, the sheet supplying ability was unstable due to the change in the outer configuration of the sheet supply roller because of the frictional wear, the change in the material of the sheet supply roller through the elapsed time and the change in the coefficient of friction of the roller surface because of the adhesion of paper powder, and other sheets having different surface conditions could not be handled.

To avoid this, recently, there has been proposed a sheet supply apparatus (referred to as "air sheet supply apparatus" hereinafter) in which sheets stacked on a sheet stacking tray is absorbed and conveyed by utilizing an absorbing force of air and a conveying force of an endless belt. FIG. **49** shows a typical example of such air sheet supply apparatus. A sheet convey portion **100** is arranged above a sheet stacking tray **101** on which a plurality of sheets S are stacked. The sheet convey portion **100** comprises a sheet absorb means **102**, a convey belt **103** having a plurality of air openings **103A**, and a blower **104** for absorbing or sucking air below the convey belt **103** through the air openings **103A** and an opening **102A** of the sheet absorb means **102**.

A nozzle **105** for injecting air to float an uppermost sheet S and a nozzle **106** for injecting air against second, third and other sheets S to separate the uppermost sheet S from the other sheets are arranged in the proximity of a tip end of the sheet stack S rested on the sheet stacking tray **101**. The nozzles **105**, **106** are connected to a blower **107** so that the air is supplied to these nozzles.

In this air sheet supply apparatus, in order to supply the sheets S stacked on the sheet stacking tray **101**, first of all, the air is injected from the nozzle **105** by the action of the blower **107** to float several sheets S on the sheet stacking tray **101**. Then, by the absorbing force of the sheet absorb means **102** generated by the action of the blower **104**, the uppermost sheet S is absorbed to a sheet absorb surface **103B** of the convey belt **103**. Thereafter, the convey belt **103** is rotated in a direction shown by the arrow to convey the sheet absorbed to the convey belt **103** in a downstream direction. In this case, the air from the nozzle **106** is blown against a tip end of the sheet S by the action of the blower **107**, thereby separating the double-fed second and other sheets (if any) from the uppermost sheet S. In this way, only the uppermost sheet S is sent to a pair of convey rollers **108**.

Incidentally, in this air sheet supply apparatus, the sheet S floated by the air from the nozzle **105** and absorbed to the sheet absorb surface **103B** of the convey belt **103** by the absorbing force of the sheet absorb means **102** is absorbed to the sheet absorb surface **103B** of the convey belt **103** in a condition that the sheet is substantially parallel with the

convey belt through the whole length of the sheet. Further, the endless convey belt **103** extends between and wound around two rollers **109**, **110** arranged on both sides of the sheet absorb means **102**. In this example, the downstream roller **109** is a drive roller rotated by a motor **111**, and the upstream roller **110** is a driven roller.

Incidentally, the air generated by the blower **107** flows toward the nozzle **105** when a valve **112** is switched to a position a, and flows toward the nozzle **106** when the valve **112** is switched to a position b. Further, the sheet absorb means **102** is so designed that the absorbing force is generated by the action of the blower **104** when a valve **113** is in a position c, and the absorbing force is not generated when the valve **113** is in a position d.

By the way, in the above-mentioned air sheet supply apparatus, an important factor for separating the sheets S is to surely blow the air from the nozzle **106** between the first sheet S1 to be conveyed and the second sheet S2 to be separated. As shown in FIG. **50**, when the air from the nozzle **106** is blown between the first sheet S1 and the second sheet S2, the positive pressure is generated between the sheets, with the result that a downwardly directing force for aiding the separation acts on the second sheet S2 and an upwardly directing force for aiding the absorption of the sheet to the convey belt **103** acts on the first sheet S1. Thus, the first sheet S1 is separated from the second sheet S2. In this way, when any gap exists between the tip end of the first sheet S1 to be conveyed and the tip end of the second sheet S2 to be separated, the air from the nozzle **106** can enter between the sheets S1, S2 to separate the second sheet S2 from the first sheet S1.

However, in the above-mentioned conventional air sheet supply apparatus in which the sheet S floated by the air from the nozzle **105** and absorbed to the sheet absorb surface **103B** of the convey belt **103** by the absorbing force of the sheet absorb means **102** is absorbed to the sheet absorb surface **103B** of the convey belt **103** in the condition that the sheet is substantially parallel with the convey roller through the whole length of the sheet, the second sheet S2 sometimes could not be separated from the first sheet S1.

That is to say, as shown in FIG. **51**, if the tip end of the first sheet S1 is closely contacted with the tip end of the second sheet S2 due to the sticking between fibers of first and second sheets and/or the flash of the cut edges of the sheets generated by the poor cutting, the air from the nozzle **106** will not enter between the first sheet S1 and the second sheet S2, with the result that the positive pressure is generated below the second sheet S2. Accordingly, in this case, the air acts on the undersurface of the second sheet S2 to promote the close contact between the first sheet S1 and the second sheet S2. In particular, in thin sheets, it is feared that the second sheet S2 is absorbed to the convey belt **103** together with the first sheet S1 by the absorbing force of the air from the air openings **103A** of the convey belt **103**.

In this way, when the tip end of the first sheet is closely contacted with the tip end of the second sheet, it is impossible to separate the second sheet S2 from the first sheet S1. As a result, there arose a problem that the double-feed of the sheets could not be prevented. Further, in order to prevent the double-feed, if the force of the air injected from the nozzle **106** becomes stronger, the first sheet S1 to be conveyed will also be blown out.

SUMMARY OF THE INVENTION

The present invention aims to eliminate the above-mentioned conventional drawbacks, and an object of the present invention is to provide a sheet supply apparatus in which, even if a tip end of a first sheet is closely contacted with a tip end of a second sheet due to the sticking between fibers of these sheets, the first sheet can surely be separated from the second sheet, thereby preventing the double-feed of the sheets.

To achieve the above object, according to the present invention, there is provided a sheet supply apparatus comprising a sheet stacking means on which a plurality of sheets can be stacked, a first air absorb means arranged in opposition to a sheet surface of a sheet stack rested on the sheet stacking means and adapted to absorb a sheet by air suction, a second sheet absorb means arranged at a tip end side of the sheet surface in a sheet convey direction and adapted to absorb a tip end of the sheet by air action, and a convey means for conveying the sheet absorbed by the first and second sheet absorb means, and wherein the first and second sheet absorb means are arranged at positions having different distances from the sheet surface and the sheets are separated one by one by averting the tip end of the sheet.

With the arrangement as mentioned above, since the distance between the first sheet absorb means and the sheet surface is different from the distance between the second sheet absorb means and the sheet surface and since the tip end of the sheet is averted by these sheet absorb means, for example, even if two sheets are absorbed by these sheet absorb means, an upper sheet is directly absorbed by these sheet absorb means to avert the tip end of the sheet. On the other hand, a lower sheet tries to maintain a natural substantially horizontal attitude along a third sheet by its own weight and restoring force. Further, as the sheets continue to be conveyed, the averted tip end portion of the sheet is gradually increased so that a distance between the tip end of the upper sheet and the tip end of the lower sheet is gradually increased.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is an elevational sectional view of a sheet supply apparatus according to a first embodiment of the present invention;

FIG. **2** is an elevational sectional view of a sheet supply apparatus according to a second embodiment of the present invention;

FIG. **3** is an elevational sectional view of a sheet supply apparatus according to a third embodiment of the present invention;

FIG. **4** is an elevational sectional view showing an example of an image forming apparatus having the sheet supply apparatus of the present invention;

FIG. **5** is an elevational sectional view of a sheet supply apparatus according to a fourth embodiment of the present invention;

FIG. **6** is an elevational sectional view of the apparatus of FIG. **5** in its operative condition;

FIG. **7** is an elevational sectional view of a sheet supply apparatus according to a fifth embodiment of the present invention;

FIG. **8** is a control block diagram of the apparatus of FIG. **7**;

FIG. **9** is a control block diagram of a sheet supply apparatus according to a sixth embodiment of the present invention;

FIG. **10** is an elevational sectional view of a sheet supply apparatus according to a seventh embodiment of the present invention;

FIG. **11** is a plan view of nozzles and therearound of the apparatus of FIG. **10**;

FIG. **12** is a view looked at along the arrow of FIG. **11**;

FIG. **13** is an elevational sectional view of the apparatus of FIG. **10** in its operative condition;

FIG. **14** is an elevational sectional view of a sheet supply apparatus according to an eighth embodiment of the present invention;

FIG. **15** is an elevational sectional view of a sheet supply apparatus according to a ninth embodiment of the present invention;

FIGS. **16A** to **16D** are sectional views showing the operation of the apparatus of FIG. **15**;

FIG. **17** is an elevational sectional view of a sheet supply apparatus according to a tenth embodiment of the present invention;

FIGS. **18A** to **18D** are sectional views showing the operation of the apparatus of FIG. **17**;

FIG. **19** is an elevational sectional view of a sheet supply apparatus according to an eleventh embodiment of the present invention;

FIGS. **20A** to **20C** are sectional views showing the operation of the apparatus of FIG. **19**;

FIG. **21** is an elevational sectional view of a sheet supply apparatus according to a twelfth embodiment of the present invention;

FIGS. **22A** to **22C** are sectional views showing the operation of the apparatus of FIGS. **20A** to **20C**;

FIG. **23** is an elevational sectional view of a sheet supply apparatus according to a thirteenth embodiment of the present invention;

FIG. **24A** is an elevational sectional view of a sheet supply apparatus according to a fourteenth embodiment of the present invention, FIG. **24B** is a perspective view of a pressure paddle of the apparatus of FIG. **24A**;

FIG. **25** is an elevational sectional view of a sheet supply apparatus according to a fifteenth embodiment of the present invention;

FIG. **26** is an elevational sectional view of the apparatus of FIG. **25** in its operative condition;

FIG. **27** is an elevational sectional view of a sheet supply apparatus according to a sixteenth embodiment of the present invention;

FIG. **28** is an elevational sectional view of a sheet supply apparatus according to a seventeenth embodiment of the present invention;

FIGS. **29A** and **29B** are sectional views of a sheet supply apparatus according to an eighteenth embodiment of the present invention, looked at from a downstream side of a sheet convey direction;

FIGS. **30A** and **30B** are bottom views of the apparatus of FIGS. **29A** and **29B**;

FIG. **31** is a plan view of a shutter member of the apparatus of FIGS. **29A** and **29B**;

FIGS. **32A** and **32B** are bottom views of a sheet supply apparatus according to a nineteenth embodiment of the present invention;

FIG. **33** is a plan view of a shutter member of the apparatus of FIGS. **32A** and **32B**;

FIG. **34** is a control timing chart of a sheet supply apparatus according to a twentieth embodiment of the present invention;

FIG. 35 is an elevational sectional view of a sheet supply apparatus of other type applying the twentieth embodiment;

FIGS. 36A to 36C are sectional views showing the operation of a sheet supply apparatus according to a twenty-first embodiment of the present invention;

FIG. 37 is a sectional view showing the operation of a sheet supply apparatus according to a twenty-second embodiment of the present invention;

FIG. 38 is an elevational sectional view of a sheet supply apparatus according to a twenty-third embodiment of the present invention;

FIG. 39 is an elevational sectional view of a sheet supply apparatus according to a twenty-fourth embodiment of the present invention;

FIGS. 40 and 41 are elevational sectional views of the apparatus of FIG. 39 in its operative condition;

FIG. 42 is a bottom view of a sheet supply apparatus according to a twenty-fifth embodiment of the present invention;

FIG. 43 is a bottom view of a sheet supply apparatus according to a twenty-sixth embodiment of the present invention;

FIG. 44 is a bottom view of a sheet supply apparatus according to a twenty-seventh embodiment of the present invention;

FIG. 45 is an elevational sectional view of a sheet supply apparatus according to a twenty-eighth embodiment of the present invention;

FIG. 46 is a drive timing chart of the apparatus of FIG. 45;

FIG. 47 is a bottom view of a sheet supply apparatus according to a twenty-ninth embodiment of the present invention;

FIG. 48 is a bottom view of a sheet supply apparatus according to a thirtieth embodiment of the present invention;

FIG. 49 is an elevational sectional view showing an example of a conventional air sheet supply apparatus; and

FIGS. 50 and 51 are sectional views showing the operation of the apparatus of FIG. 49.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

First of all, a first embodiment of the present invention will be explained with reference to FIG. 1.

FIG. 1 shows a whole construction of an air sheet supply apparatus according to a first embodiment of the present invention. In FIG. 1, a plurality of sheets S are stacked on a sheet stacking tray 1, and tip ends of the sheets S are abutted against an alignment guide plate 2. A sheet convey portion 3 is provided with a first sheet absorb means 4 which comprises a flat bottom plate 5 opposed to a sheet stack rested on the sheet stacking tray 1, an air absorb opening 6 formed in the bottom plate 5, and a suction chamber 7.

A second sheet absorb means 8 comprises a flat bottom plate 9 disposed at a downstream side of the flat bottom plate 5 in a sheet convey direction and inclined upwardly from the bottom plate 5 by a predetermined angle θ, an air absorb opening 10 formed in the bottom plate 9, and a suction chamber 11. The suction chambers 7, 11 is communicated with an air absorb blower 12. The absorbing action of the blower 12 is ON/OFF controlled by a valve 13.

An endless convey belt 14 is mounted on and around rollers 15, 16, 17 and 18 in such a manner that the whole bottom surfaces of the sheet absorb means 4, 8 are covered by the convey belt. The convey belt 14 has a plurality of air openings 14A formed therein. The convey belt 14 is supported by the rollers 15, 16, 17 and 18 with a predetermined tension and is intermittently driven in a direction shown by the arrow A by a drive means (not shown), thereby conveying the sheet. The roller 15 is disposed at the intersection between the horizontal flat bottom plate 5 and the inclined flat bottom plate 9 and acts as a displacement fulcrum portion 15A for displacing or bending the sheet in such a manner that the sheet becomes convex downwardly. As a result, the tip end of the sheet S sucked by the second sheet absorb means 8 is absorbed to a tip end portion 14B of the convey belt 14 inclined by a predetermined angle.

A nozzle 19 serves to inject air in order to float the sheets S stacked on the sheet stacking tray 1, and a nozzle 20 serves to inject air in order to separate a single sheet from the other sheets. The nozzles 19, 20 are connected to an air injection blower 21. The injection of the air from the nozzles 19, 20 can selectively be switched by a valve 22. A pair of convey rollers 23 serve to convey the sheet S conveyed by the convey belt 14 in a downstream direction.

Next, the operation of the air sheet supply apparatus will be explained.

First of all, the valve 22 is switched to a position a by a switch means (not shown) such as a solenoid so that the blower 21 is operated to inject the air from the nozzle 19 toward the tip end of the sheet stack rested on the sheet stacking tray 1. As a result, several sheets S are blown up to float.

Then, the valve 13 is switched to a position c by a switch means such as a solenoid so that the blower 12 is operated to suck or absorb the air below the convey belt 14 through the absorb openings 6, 10 and the air openings 14A. As a result, a first (uppermost) sheet S1 is absorbed to the sheet absorb means 4, 8 so that the sheet is adhered to the convey belt 14. More specifically, as shown in FIG. 1, a central portion of the sheet S1 is absorbed to the sheet absorb means 4 and the tip end portion of the sheet S1 is absorbed to the sheet absorb means 8. In this case, since the absorbing forces of the sheet absorb means 4, 8 are set to be sufficiently strong, the sheet S1 is bent around the displacement fulcrum portion 15A in opposition to the resilience of the sheet itself, so that the tip end portion and the central portion of the sheet is adhered to the convey belt 14. That is to say, the sheet S1 follows the flat bottom plates 5, 9 to bend around the displacement fulcrum portion 15A so that the sheet becomes convex downwardly.

Now, it is assumed that a second sheet S2 is closely contacted with the first sheet S1. In this case, a central portion of the second sheet S2 substantially follows the first sheet S1. However, since the surface of the sheet absorb means 8 is covered by the sheet S1, the absorbing force does not act on the tip end portion of the sheet S2. Accordingly, the second sheet S2 is not bent around the displacement fulcrum portion 15A in opposition to the resilience of the sheet to maintain the flat condition, so that the tip end of the sheet S2 is separated from the tip end of the sheet S1 to create a gap e between the sheets S1 and S2.

Then, the convey belt 14 is driven by the drive means (not shown) to convey the sheet S1 in the direction shown by the arrow A. At the same time, the valve 22 is switched to a position b to inject the air from the nozzle 20 into the gap e between the sheets S1 and S2, so that, as shown in FIG. 1, the sheet S2 is surely separated from the sheet S1. Accordingly, only the sheet S1 is conveyed toward the downstream direction to be brought to the paired convey rollers 23. Incidentally, the operations of the blowers 12, 21 and the operation of the drive means for the convey belt 14 are controlled by a control means.

FIG. 2 shows a whole construction of an air sheet supply apparatus according to a second embodiment of the present invention. Incidentally, in this air sheet supply apparatus, the same constructural elements as those of the air sheet supply apparatus according to the first embodiment are designated by the same reference numerals and the detailed explanation thereof will be omitted.

A second sheet absorb means **140** is disposed at a downstream side of the first sheet absorb means **4** in the sheet convey direction. The second sheet absorb means **140** comprises a hollow absorb roller **141** having a plurality of air openings **141A** formed in a surface of the roller, a suction chamber **142**, and a cover **143** for substantially covering a portion of the absorb roller **141** other than a sheet absorbing portion of the roller. Since the sheet absorbing portion of the absorb roller **141** has a curvature, it is positioned substantially above the flat bottom plate **5** of the sheet absorb means **4**. The chambers **7**, **142** are communicated with the blower **12**.

The convey belt **14** is mounted on and around rollers **15**, **16**, **17** and **18** in such a manner that the whole bottom surface of the sheet absorb means **4** is covered by the convey belt. The convey belt **14** is supported by the rollers **15**, **16**, **17** and **18** with a predetermined tension and is intermittently driven in the direction shown by the arrow A by the drive means (not shown), thereby conveying the sheet.

Next, the operation of this air sheet supply apparatus will be explained.

First of all, the valve **22** is switched to the position a by the switch means (not shown) such as a solenoid so that the blower **21** is operated to inject the air from the nozzle **19** toward the tip end of the sheet stack rested on the sheet stacking tray **1**. As a result, several sheets S are blown up to float.

Then, the valve **13** is switched to the position c by the switch means such as a solenoid so that the blower **12** is operated to suck or absorb the air through the absorb opening **6** and the air openings **141A**, **14A**. As a result, the first (uppermost) sheet S1 is absorbed to the sheet absorb means **4**, **140** so that the sheet is adhered to the convey belt **14**. More specifically, as shown in FIG. 2, the central portion of the sheet S1 is absorbed to the sheet absorb means **4** and the tip end portion of the sheet S1 is absorbed to the sheet absorb means **140**. Since a surface of the sheet absorb means **140** has the predetermined curvature, the tip end of the sheet S1 is lifted upwardly substantially along the curvature in opposition to the resilience of the sheet and is adhered to the convey belt **14**. That is to say, the sheet S1 is bent around a position from which the convey belt **14** starts to be curved (i.e., a position **144** where the absorb roller **141** is contacted with the convey belt **14**) so that the sheet S1 becomes convex downwardly.

Then, as in the first embodiment, when the sheet S1 is conveyed while injecting the air into the gap e between the sheets S1 and S2, the sheet is conveyed toward the downstream direction without the double-feed.

FIG. 3 shows a construction of an air sheet supply apparatus according to a third embodiment of the present invention. The construction of this air sheet supply apparatus is substantially the same as the air sheet supply apparatus according to the first embodiment fundamentally.

In this air sheet supply apparatus, the rollers **15**, **18** and the sheet absorb means **4** are arranged so that a straight line L1 connecting between lower ends of the rollers **15** and **18** is positioned toward the surface of the sheet stack more than the flat bottom surface **5** of the sheet absorb means **4**. Further, the rollers **15**, **16** and the sheet absorb means **8** are arranged so that a straight line L2 connecting between lower ends of the rollers **15** and **16** is positioned toward the surface of the sheet stack more than the flat bottom surface **9** of the sheet absorb means **8**.

Further, in this air sheet supply apparatus, the roller **18** is a drive roller driven by a motor **70** to rotate the convey belt **14**, and the other rollers **15**, **16** and **17** are driven roller rotated by the movement of the convey belt **14**. When a driving force is transmitted from the motor **70** to the roller **18** to rotate the convey belt in the direction shown by the arrow A, the convey belt **14** is tensioned between the rollers **17** and **18** and is loosened between the rollers **18** and **15** and between the rollers **15** and **16**.

Next, the operation of this air sheet supply apparatus will be explained.

First of all, the valve **22** is switched to the position a by the switch means (not shown) such as a solenoid so that the blower **21** is operated to inject the air from the nozzle **19** toward the tip end of the sheet stack rested on the sheet stacking tray **1**. As a result, several sheets S are blown up to float.

Then, the valve **13** is switched to the position c by the switch means such as a solenoid so that the blower **12** is operated to such or absorb the air below the convey belt **14** through the absorb openings **6**, **10** and the air openings **14A**. As a result, the first (uppermost) sheet S1 is absorbed to the sheet absorb means **4**, **8** so that the sheet is adhered to the convey belt **14**. In this case, since the convey belt **14** is loosened between the rollers **18** and **15** and between the rollers **15** and **16**, the loosened portions of the convey belt are absorbed to the sheet absorb means **4** and the sheet absorb means **8**, respectively, together with the sheet S1 and are slightly contacted with the flat bottom plates **5**, **9** of the sheet absorb means **4**, **8**, respectively.

Since the separation and conveyance of the sheet which are then effected are the same as those in the first embodiment, the explanation thereof is omitted.

Incidentally, in this embodiment, while the roller **18** associated with the convey belt **14** was drive roller, the roller **15** may be a drive roller. In this case, since the roller disposed at the upstream side of the sheet absorb means **8** (i.e., roller **15**) is the drive roller, a portion of the convey belt **14** between the rollers **15** and **16** is loosened, with the result that the tip end portion of the sheet can be absorbed effectively.

Now, FIG. **4** shows an example of an image forming apparatus (copying machine) having the sheet supply apparatus of the present invention.

The image forming apparatus **200** is provided with an original support **206**, a light source **207**, a lens system **208**, a sheet supply portion **209** and an image forming portion **202**. The sheet supply portion **209** has cassettes **210**, **211** adpated to contain sheets S and removably mounted to the image forming apparatus **200**, and a deck **213** arranged on a pedestal **212**. The sheet supply apparatus of the present invention is mounted on the deck **213**. The image forming portion **202** includes a cylindrical photosensitive member **214**, a developing device **215** containing toner, a transfer charger **216**, a separation charger **217**, a cleaner **218** and a first or primary charger **219**. A convey device **220**, a fixing device **204** and discharge rollers **295** are arranged at a downstream side of the image forming portion **202**.

Next, the operation of the image forming apparatus will be explained. When a sheet supply signal is outputted from a control device (not shown) of the image forming apparatus **200**, the sheet S is supplied from the cassette **210** or **211** of the deck **213**. On the other hand, light omitted from the light source **207** and reflected from an original D rested on the

original support 206 is incident to the photosensitive member 214 through the lens system 208. The photosensitive member 214 is previously charged by the primary charger 219. Accordingly, when the photosensitive member is illuminated by the reflected light, an electrostatic latent image is formed on the photosensitive member, which latent image is then developed by the developing device 215 as a toner image.

The sheet S supplied from the sheet supply portion 209 is sent to regist rollers 201, where the skew-feed of the sheet is corrected. Then, the sheet is sent to the image forming portion 202 with a predetermined timing. In the image forming portion 202, the toner image formed on the photosensitive member 214 is transferred onto the sheet S by the transfer charger 216, and then the sheet to which the toner image was transferred is separated from the photosensitive member 214 by applying to the sheet the charge opposite to that of the transfer charger 216 by the separation charger 217. The separated sheet S is sent, by the convey device 220, to the fixing device 204, where the transferred non-fixed image is permanently fixed to the sheet. The sheet S to which the image was fixed is discharged out of the image forming apparatus 200 by the discharge rollers 205.

In this way, the sheet S which was supplied from the sheet supply portion 209 and on which the image was formed is discharged.

Next, a fourth embodiment of the present invention will be explained with reference to FIG. 5.

This embodiment differs from the first embodiment only in the point that an angle θ of the displacement fulcrum portion 15A is variable. The same constructural elements as those of the first embodiment are designated by the same reference numerals and the detailed explanation thereof will be omitted, and the only difference will be fully explained.

In FIG. 5, an angle adjustment shaft support plate 25 for rotatably supporting the rollers 15, 16 is rotatably mounted on a roller shaft of the roller 15, and an angle adjustment arm 26 is rotatably attached to the angle adjustment support plate 25. A stopper shaft 27 is provided on the other end of the angle adjustment arm 26 so that the stopper shaft 27 can be locked in a recess 28A or 28B of a stopper 28. These recesses serve to previously set an angle θ (referred to as "separation angle" hereinafter) to an angle satisfying the following two conditions in response to the resilience of the sheet S to be conveyed. The first condition is that only the uppermost sheet S1 is completely absorbed to the second sheet absorb means 8, and the second condition is that a force for maintaining the lower sheet S2 to a flat attitude by the resilience of the sheet is greater than a force bending the lower sheet S2 absorbed together with the uppermost sheet S1 around the displacement fulcrum portion 15A to become convex downwardly.

Next, the operation of this air sheet supply apparatus in a case where the resilience of the sheet is great will be explained with reference to FIG. 5. When the resilience of the sheet is great, if the separation angle θ is great, since the uppermost sheet S1 is stabilized and is not absorbed to the second sheet absorb means 8, the separation angle θ is set to be small. In this case, the stopper shaft 27 is introduced into the recess 28A of the stopper 28. Thereafter, the valve 22 is switched to the position b by the switch means (not shown) such as a solenoid so that the blower 21 is operated to inject the air from the first nozzle 19 toward the tip end of the sheet stack So As a result, several sheets S are blown up to float. Then, the valve 13 is switched to the position c by the switch means (not shown) such as a solenoid so that the blower 12 is operated to absorb the air through the air absorb openings 6, 10 and the air openings 14A.

Consequently, the uppermost sheet S1 is absorbed to the first and second sheet absorb means 4, 8 and is adhered to the convey belt 14. More specifically, as shown in FIG. 5, the central portion of the sheet S1 is absorbed to the first sheet absorb means 4 and the tip end portion of the sheet S1 is absorbed to the second sheet absorb means 8. In this case, since the separation angle θ was previously set to be small, the sheet S1 is bent around the displacement fulcrum portion 15A in opposition to the resilience of the sheet S1, so that the tip end portion and the central portion of the sheet S1 are closely adhered to the convey belt 14. That is to say, the sheet S1 substantially follows the flat bottom plate 5 and is bent around the displacement fulcrum portion 15A to become convex downwardly. In this case, since the separation angle θ was previously set to be small as mentioned above, the lower sheet S2 is not bent around the displacement fulcrum portion 15A to maintain the flat attitude, with the result that the tip end of the sheet S2 is separated from the tip end of the sheet S1 to create the gap e therebetween.

Thereafter, the convey belt 14 is driven by the drive means to convey the uppermost sheet S1 in the direction shown by the arrow A. At the same time, the valve 22 is switched to the position b, with the result that the air from the second nozzle 20 is blown into the gap e between the sheets S1 and S2, thereby separating the sheet S2 stably. Accordingly, only the sheet S1 is conveyed in the downstream direction to be sent to the paired convey rollers 23.

Next, a case where the resilience of the sheet is weak will be explained with reference to FIG. 6. In the case where the resilience of the sheet S is weak, if the separation angle θ is small, when the uppermost sheet S1 is absorbed, since the lower sheet S2 is apt to be absorbed together with the uppermost sheet, the separation angle θ is set to be great. In this case, the stopper shaft 27 is introduced into the recess 28B of the stopper. By increasing the separation angle θ in this way, the sheet having the weak resilience can also be surely separated.

In this fourth embodiment, while an example that the separation angle θ can be varied with two stages was explained, the present invention is not limited to this example, but the separation angle may be varied with any plural stages or in a stageless manner. Further, it should be noted that a range of the separation angle θ (including 0°) may be appropriately set.

Next, a fifth embodiment of the present invention will be explained with reference to FIG. 7. Incidentally, in an air sheet supply apparatus according to the fifth embodiment, the same constructural elements as those of the first embodiment are designated by the same reference numerals and the detailed explanation thereof will be omitted.

In the aforementioned fourth embodiment, the time period from when the first and second sheet absorb means 4, 8 start to the suction to when the convey belt 14 starts to drive was normally constant. However, since the second absorb means 8 is spaced apart from the uppermost surface of the sheet stack S rested on the sheet stacking tray 1, depending upon the kinds of the sheet (thick sheet, thin sheet or the like) and the change in the sheet supply environment, the time period from when the second sheet absorb means 8 starts to the suction to when the sheet S is absorbed to the second sheet absorb means 8 was varied. Accordingly, if the convey belt 14 starts to drive before the sheet S is absorbed to the second sheet absorb means 8, it was feared that the poor sheet supply occurs. To avoid this, if the time period from when

the second sheet absorb means 8 starts to the suction to when the convey belt 14 starts to drive becomes long sufficient to surely absorb the sheet S to the second sheet absorb means 8, the sheet supply cycle will be longer, thereby reducing the number of sheets supplied per unit time.

Thus, as shown in FIG. 7, a sheet detection portion (detection means) 35 comprising a flag 31 pivotally mounted on a shaft 30, a photo-sensor 32 and a stopper 33 is provided on the second sheet absorb means 8 so that it can be judged whether the sheet S is absorbed to the second sheet absorb means 8 or not.

FIG. 8 shows a control block diagram of the air sheet supply apparatus according to the fifth embodiment. A detection signal from the sheet detection portion 35 is inputted to a control means 36, and the control means 36 controls a convey belt drive means 37 and a valve switch means 38.

The flag 31 is rocked by the sheet S absorbed to the second sheet absorb means 8 to be shifted to a condition f, thereby detecting the suction of the sheet S by the photo-sensor 32. When the detection signal outputted from the photo-sensor 32 is inputted to the control means 36, the convey belt 14 is driven by the convey belt drive means 37, thereby conveying the sheet S1 in the direction shown by the arrow A. At the same time, the valve 22 is switched to the position b by the valve switch means 38 to inject air from the second nozzle 20 into the gap e between the sheets S1 and S2, thereby separating the sheet S2 stably. Accordingly, only the sheet S1 is conveyed toward the downstream direction to be sent to the paired convey rollers 23.

In the above-mentioned fifth embodiment, while an example that the timing for starting the drive of the convey belt 14 is the timing for detecting the sheet S by the sheet detection portion 35 was explained, the present invention is not limited to this example. For example, it is assumed that the time when the valve 13 is switched to the position c is t=0, the time period until the sheet S is detected by the sheet detection portion 35 is $t=T_2$, and any time period from when the valve 13 is switched to the position c is $t=T_1$, when $T_2<T_1$ the drive of the convey belt 14 may be started at $t=T_1$ and when $T_2>T_1$ the drive of the convey belt 14 may be started at $t=T_2$. Thus when the time period T_2 is set to a certain large extent, since the drive of the convey belt 14 is started at $t=T_1$ in the normal sheet supply operation, and the drive of the convey belt is started at $t=T_2$ only when the suction of the sheet S to the second sheet absorb means 8 is delayed suddenly, it is possible to achieve the stable sheet supply operation.

Incidentally, in this fifth embodiment, while an example that the separation angle θ is constant was explained, the present invention is not limited to this example.

Next, a sixth embodiment of the present invention will be explained with reference to FIG. 9. Incidentally, in an air sheet supply apparatus according to the sixth embodiment, the same constructural elements as those of the fifth embodiment are designated by the same reference numerals and the detailed explanation thereof will be omitted.

In this sixth embodiment, as shown in FIG. 9, the control means 36 also controls a blower output adjust means 39 for adjusting the output of the blower 12, as well as the aforementioned valve switch means 38 and convey belt drive means 37. It is assumed that the time when the valve 13 is switched to the position c is t=0, the time period until the sheet S is detected by the sheet detection portion 35 is $t=T_2$, and any time period from when the valve 13 is switched to the position c is $t=T_1$, when $T_2>T_1$, the output of the blower 12 is increased by the control means 36 to increase the absorbing force of the second sheet absorb means 8. In this way, even a sheet S which is hard to be absorbed to the second sheet absorb means 8 can be absorbed surely and quickly. Thereafter, as in the aforementioned fifth embodiment, the convey belt 14 is driven by the convey belt drive means 47 to start the sheet supply operation.

Incidentally, the output adjust means may be provided on the blower 21 in place of the blower 12 so that the blowing force of the first nozzle 19 is increased to absorb the sheet S to the second sheet absorb means 8. Of course, in place of the blower output adjust means, a switching valve and the like may be provided to adjust the absorbing force and/or the blowing force.

Incidentally, in the sixth embodiment, while an example that the separation angle θ is constant was explained, the present invention is not limited to this example.

Next, a seventh embodiment of the present invention will be explained with reference to FIGS. 10 to 13. Incidentally, in an air sheet supply apparatus according to the seventh embodiment, the same constructural elements as those of the fourth embodiment are designated by the same reference numerals and the detailed explanation thereof will be omitted.

In the aforementioned fourth embodiment, since the air from the second nozzle 20 is blown in the proximity of the tip end portion B (FIG. 10) of the sheet S absorbed to the second sheet absorb means 8 to separate the lower sheet S2, it is required to adjust the blowing position of the second nozzle 20 against the second sheet absorb means 8 with high accuracy. In particular, when the second sheet absorb means 8 is movable, since the second nozzle 20 is integrally formed with the first nozzle 19 and the blower 21, in response to the change in the separation angle θ between the first sheet absorb means 4 and the second sheet absorb means 8, it was feared that the position of the second nozzle 20 is deviated with respect to the tip end portion B of the sheet S.

To avoid this, as shown in FIG. 10, the second nozzle 20 is secured to the angle adjustment support plate 25 by a nozzle attachment plate 40 and the second nozzle is connected to the blower 21 via a flexible duct 41. With this arrangement, the air injected from the second nozzle 20 can always impinge against the tip end portion B of the sheet S, thereby eliminating the above-mentioned disadvantage.

FIG. 11 is a schematic top view of the second nozzles 20 and thereabout of FIG. 10, and FIG. 11 is a view looked at along the arrow C in FIG. 11. The second nozzles 20 are pinched by nozzle stays 45, 46 and are fixed to the nozzle stays by screws 47. Further, the nozzle stays 45, 46 are secured to the nozzle attachment plate 40 by screws 48, which nozzle attachment plate 40 is secured to the angle adjustment support plate 25 by screws 49. FIG. 13 shows a condition that the separation angle θ is increased. In this condition, when the angle adjustment support plate 25 is shifted, the second nozzles 20 are also shifted, and, thus, since the angle between the second nozzles and the flat bottom plate 9 of the second sheet absorb means 8 is not varied, the sheet can be separated regardless of the separation angle θ.

Next, an eighth embodiment of the present invention will be explained with reference to FIG. 14. Incidentally, in an air sheet supply apparatus according to the eighth embodiment, the same constructural elements as those of the first embodiment are designated by the same reference numerals and the detailed explanation thereof will be omitted.

When the sheet is jammed in the image forming apparatus, the delay and stay of the sheet is detected by a jam detection sensor, thereby immediately stopping the image forming operation of the image forming apparatus (in this case, the blower 21 is also stopped). In this case, it is assumed that the sheet S1 is stopped at a position x shown in FIG. 14. In this position, the sheet was discharged from the sheet stacking tray 1 but is not pinched by the paired convey rollers 23 (since the sheet S situated in this position is not pinched by the paired convey rollers 23, wrinkles and other damages are not generated in the sheet). That is to say, in this case, the presence of the sheet S is detected by a detection sensor 53 provided in the air sheet supply apparatus, and the absence of the sheet S is detected by a detection sensor 54. In this condition, even when the operation of the image forming apparatus is stopped by the detection of the jam detection sensor 50 (or 51 or 52), the blower 12 continues to operate, with the result that the sheet S1 continues to be adhered to the convey belt 14.

Thereafter, when a motor M is driven reversely, the convey belt 14 is driven in a direction (shown by the arrow D) opposite to the sheet convey direction, thereby conveying the sheet S1 toward the upstream direction. When the sheet S1 is returned above the sheet stacking tray 1 to pass the tip end of the sheet S1 through the detection sensor 53 (which now detects the absence of the sheet), the motor M is stopped to stop the convey belt 14. Thereafter, the blower 12 is also stopped, with the result that the sheet S1 drops onto the sheet stacking tray 1, thereby preparing the waiting condition for the next image forming operation. After these series of operations, by removing the jammed and damaged sheet from the image forming apparatus, the jam treatment is effected without removing the reusable sheet S1 and the jam treatment time can be reduced.

When the jammed condition is detected, if the sheet S is detected by the detection sensor 54, the above-mentioned series of operations are not performed, and the image forming apparatus is stopped immediately, because, in this case, the sheet S is pinched by the paired convey rollers 23 and it is feared that the sheet S is damaged. When the jammed condition is detected, unless the sheet S is detected by the detection sensors 53, 54 simultaneously, the above-mentioned series of operations are also not performed, and the image forming apparatus is stopped immediately, because, in this case, there is no sheet in these areas.

Next, a ninth embodiment of the present invention in which a means for improving the separability of the sheet is provided in the air sheet supply apparatus of the first embodiment will be explained.

FIG. 15 shows a whole construction of a sheet supply apparatus according to the ninth embodiment.

Incidentally, in this sheet supply apparatus, the same constructural and functional elements as those of the sheet supply apparatus of the first embodiment are designated by the same reference numerals and the detailed explanation thereof will be omitted. This is also applied to a sheet supply apparatus according to a tenth embodiment.

In this sheet supply apparatus, a sheet push rod (sheet pushing means) 324 having a roller 324A at its free end is disposed in the proximity of the upstream end of the convey belt 14, which sheet push rod is arranged not to overlap with the convey belt 14. A bias spring 325 serves to bias the sheet push rod 324 upwardly, and a solenoid 326 is connected to the sheet push rod 324. The solenoid 326 is turned ON when the sheet S adhered to a sheet absorb surface 14H-1 of the belt 14 is pushed out by the sheet push rod 324, thereby lowering the sheet push rod 324 to a position F shown in FIG. 16B. Normally, the solenoid 326 is in an OFF condition so that the sheet push rod 324 is maintained in a position E shown in FIG. 16A.

Next, the operation of this sheet supply apparatus will be explained with reference to FIGS. 16A to 16D.

First of all, the valve 22 is switched to the position a by the switch means (not shown) such as a solenoid so that the blower 21 is operated to inject the air from the nozzles 19 toward the tip end of the sheet stack. As a result, several sheets S1, S2 are blown up to float (FIG. 16A). Then, the valve 13 is switched to the position c by the switch means such as a solenoid so that the blower 12 is operated to absorb or suck the air through the absorb openings 6, 10 and the air openings 14A. At the same time, the solenoid 326 is turned ON to lower the sheet push rod 324 to the position F (FIG. 16B).

Consequently, the air flows in areas X and Y are blocked, thereby increasing the pressures in the areas X and Y. As a result, since the pressures in the areas X and Y are greatly increased in comparison with the pressures in the chambers 11, 7, the uppermost sheet S1 is absorbed to the first and second sheet absorb means 4, 8 and is stably adhered to the sheet absorb surfaces 14H-1, 14H-2 of the convey belt 14.

Thereafter, the solenoid 326 is turned OFF, with the result that, since the pushing action of the sheet push rod 324 is released, the air flows in the areas X and Y are restored to the original condition (FIG. 16C). In this case, by the absorbing forces of the first and second sheet absorb means 4, 8, the sheet S1 is bent around the displacement fulcrum portion 15A in opposition to the resilience of the sheet, with the result that the tip end portion and the central portion of the sheet S1 are closely contacted with the sheet absorb surfaces 14H-1, 14H-2 of the convey belt 14, respectively. That is to say, the sheet S1 follows the sheet absorb surfaces 14H-1, 14H-2 to become convex downwardly around the displacement fulcrum portion 15A.

In this case, if the second sheet S2 is closely contacted with the first sheet S1, although the central portion of the sheet S2 substantially follows the sheet S1, since the surface of the second sheet absorb means 8 is covered by the first sheet S1, the tip end portion of the sheet S2 is not subjected to the absorbing force. Accordingly, since the resilience of the second sheet S2 overcomes the absorbing force, the second sheet S2 is not bent around the displacement fulcrum portion 15A to maintain the flat attitude, with the result that the tip end of the second sheet S2 is separated from the tip end of the first sheet S1, thereby creating the gap e between the sheets (FIG. 16C).

Thereafter, the convey belt 14 is driven by the drive means to convey the sheet S1 in the direction shown by the arrow A. At the same time, the valve 22 is switched to the position b, with the result that the air from the nozzles 20 is blown into the gap e between the sheets S1 and S2, thereby stably separating the sheet S2 from the sheet S1 (FIG. 16D). Accordingly, only the sheet S1 is conveyed toward the downstream direction to be sent to the paired convey rollers 23.

In this embodiment, while an example that the sheet push rod 324 pressurizes the sheet substantially along the vertical direction was explained, the present invention is not limited to this example, but the sheet push rod may push the sheet obliquely or may be rocked around a pivot to push the sheet.

FIG. 17 shows a whole construction of a sheet supply apparatus according to a tenth embodiment of the present invention.

In this sheet supply apparatus, a sheet pushing air nozzle 327 is disposed in the proximity of the upstream end of the convey belt 14, which nozzle is arranged not to overlap with the convey belt 14. A fan 330 for supplying air to the sheet pushing air nozzle 327 is connected to the air nozzle 327. A shutter 328 serves to switch ON/OFF of the air from the sheet pushing air nozzle 327. Normally, the shutter 328 is in an OFF condition.

Although the operation of this sheet supply apparatus is shown in FIGS. 18A to 18D, fundamentary, the operation is substantially the same as that of the sheet supply apparatus according to the ninth embodiment. Regarding this sheet supply apparatus, in FIG. 18B, the air is injected from the sheet pushing air nozzle 327 to push out the sheets S1, S2, so that the air flows in the areas X and Y are blocked, thereby increasing the pressures in the areas X and Y. Incidentally, in this embodiment, while an example that the air injected from the sheet pushing air nozzle pushes the sheets substantially along the vertical direction was explained, the present invention is not limited to this example, but the air from the nozzle may push the sheets obliquely.

The sheet pushing means used in the ninth and tenth embodiments provide the excellent advantage when they are applied to the conventional air sheet supply apparatus shown in FIG. 49.

Such embodiments will be explained hereinbelow. Incidentally, the same or similar constructural elements as those of the conventional apparatus shown in FIG. 49 are designated by the same reference numerals and the detailed explanation thereof will be omitted.

FIG. 19 shows a sheet supply apparatus according to an eleventh embodiment of the present invention. In this sheet supply apparatus, a sheet pressurizing rod 117 having a pressurizing roller 117A at its free end is disposed in the proximity of the downstream end of the convey belt 103, which sheet pressurizing rod is arranged not to overlap with the convey belt 103. A bias spring 118 serves to bias the sheet pressurizing rod 117 upwardly, and a solenoid 119 serves to drive the sheet pressurizing rod 117. The solenoid 119 is turned ON when the sheet S adhered to a sheet absorb surface 103H of the belt 103 is pressurized by the sheet pressurizing rod 117, thereby lowering the sheet pressurizing rod 117 to a position F shown in FIG. 20B. Normally, the solenoid 119 is in an OFF condition so that the sheet pressurizing rod 117 is maintained in a position E shown in FIG. 20A.

Next, the operation of this sheet supply apparatus will be explained.

First of all, the air is injected from the nozzle 105 by the action of the blower 107 to float several sheets S on the tray 101. By the action of the blower 104, the uppermost sheet S1 is adhered to the sheet absorb surface 103H of the convey belt 103. Now, the solenoid 119 is turned ON to lower the sheet pressurizing rod 117 to the position F shown in FIG. 20B relatively swiftly. In this case, if the second sheet S2 is closely contacted with the first sheet S1 (FIG. 20A), a gap G is created between the first sheet S1 and the second sheet S2 by the pressurizing action of the sheet pressurizing rod (FIG. 20B).

Then, the air is blown against the tip ends of the sheets S1, S2 by the action of the blower 107, thereby separating the second sheet S2 from the first sheet S1 completely. Thereafter, the solenoid 119 is turned OFF, with the result that the sheet pressurizing rod 117 is returned to its original position by the bias spring 118 (FIG. 20C).

Then, the convey belt 103 is driven, thereby sending only the first sheet S1 to the paired convey rollers 108.

In this embodiment, while an example that the sheet pressurizing rod pressurizes the sheet substantially along the vertical direction was explained, the present invention is not limited to this example, but the rod may pressurize the sheet obliquely.

FIG. 21 shows a whole construction of a sheet supply apparatus according to a twelfth embodiment of the present invention.

In this sheet supply apparatus, a sheet pressurizing air nozzle 120 is disposed in the proximity of the downstream end of the convey belt 103, which nozzle is arranged not to overlap with the convey belt 103. A fan 122 for supplying air to the sheet pressurizing air nozzle 120 is connected to the air nozzle 120. An air shutter 121 serves to switch ON/OFF of the air from the sheet pressurizing air nozzle 120. Normally, the air shutter 121 is in an OFF condition. That is to say, in this condition, the air is not injected against the sheet S adhered to the sheet absorb surface 103H of the belt 103.

Next, the operation of this sheet supply apparatus will be explained.

First of all, the air is injected from the nozzle 105 by the action of the blower 107 to float several sheets S on the tray 101. By the action of the blower 104, the uppermost sheet S1 is adhered to the sheet absorb surface 103H of the convey belt 103. The fan 122 is now operated or has previously been operated. Then, the air shutter 121 is turned ON, thereby blowing the air from the sheet pressurizing air nozzle 120 toward the sheet S. In this case, if the second sheet S2 is closely contacted with the first sheet S1 (FIG. 22A), a gap G is created between the first sheet S1 and the second sheet S2 by the pressurizing action of the sheet pressurizing air nozzle 120 (FIG. 22B).

Then, the air is blown against the tip ends of the sheets S1, S2 by the action of the blower 107, thereby separating the second sheet S2 from the first sheet S1 completely. Thereafter, the air shutter 121 is turned OFF, with the result that the air from the sheet pressurizing air nozzle 120 is stopped (FIG. 22C).

Then, the convey belt 103 is driven, thereby sending only the first sheet S1 to the paired convey rollers 108.

In this embodiment, while an example that the air from the sheet pressurizing air nozzle 120 pressurizes the sheet substantially along the vertical direction was explained, the present invention is not limited to this example, but the air may pressurize the sheet obliquely.

FIG. 23 shows a whole construction of a sheet supply apparatus according to a thirteenth embodiment of the present invention.

In this sheet supply apparatus, a sheet pressurizing oscillation rod 123, and an oscillation generation means 124 for driving the sheet pressurizing oscillation rod 123 are provided. The pressurizing oscillation rod 123 is disposed in the proximity of the downstream end of the convey belt 103 not to overlap with the convey belt 103.

The operation of this sheet supply apparatus is as follows.

First of all, the air is injected from the nozzle 105 by the action of the blower 107 to float several sheets S on the tray 101 by the action of the blower 104, the uppermost sheet S1 is adhered to the sheet absorb surface 103H of the convey belt 103. The oscillation generation means 124 is now operated to oscillate the sheet pressurizing oscillation rod 123. By oscillating the rod for a given time, a plurality of shocking forces is applied to the sheet S. In this case, if the second sheet S2 is closely contacted with the first sheet S1,

by the shocking actions of the sheet pressurizing oscillation rod **123**, a gap is created between the downstream tip ends of the first and second sheets **S1** and **S2**.

Then, the air is blown against the tip ends of the sheets **S1**, **S2** by the action of the blower **107**, thereby separating the second sheet **S2** from the first sheet **S1** completely. Thereafter, the oscillation generation means **124** is turned OFF, thereby stopping the oscillation of the sheet pressurizing oscillation rod **123**. Then, the convey belt **103** is driven, thereby sending only the first sheet **S1** to the paired convey rollers **108**.

In this embodiment, while an example that the sheet is directly oscillated by the sheet pressurizing oscillation rod **123** was explained, the present invention is not limited to this example, the sheet S may be indirectly oscillated via a portion of the convey belt **103**.

FIG. **24A** shows a whole construction of a sheet supply apparatus according to a fourteenth embodiment of the present invention.

In this sheet supply apparatus, a sheet pressurizing paddle **125** made of elastic material such as rubber is disposed in the proximity of the downstream end of the convey belt **103** not to overlap with the convey belt **103**. The sheet pressurizing paddle **125** is ON/OFF controlled, and is rotated in a direction shown by the arrow by a drive device (not shown), thereby applying the shock to the sheet S adhered to the sheet absorb surface **103H** of the convey belt **103**. Normally, the sheet pressurizing paddle **125** is in an OFF condition so that it is not rotated. FIG. **24B** is a perspective view of the sheet pressurizing paddle **125**.

The operation of this sheet supply apparatus is as follows.

First of all, the air is injected from the nozzle **105** by the action of the blower **107** to float several sheets S on the tray **101**. By the action of the blower **104**, the uppermost sheet **S1** is adhered to the sheet absorb surface **103H** of the convey belt **103**. The sheet pressurizing paddle **125** is now rotated. By rotating the paddle for a given time, a plurality of shocking forces is applied to the sheet S. In this case, if the second sheet **S2** is closely contacted with the first sheet **S1**, by the shocking actions of the sheet pressurizing paddle **125**, a gap is created between the downstream tip ends of the first and second sheets **S1** and **S2**.

Then, the air is blown against the tip ends of the sheets **S1**, **S2** by the action of the blower **107**, thereby separating the second sheet **S2** from the first sheet **S1** completely. Thereafter, the sheet pressurizing paddle **125** is stopped. Then, the convey belt **103** is driven, thereby sending only the first sheet **S1** to the paired convey rollers **108**.

FIG. **25** shows a whole construction of a sheet supply apparatus according to a fifteenth embodiment of the present invention. Incidentally, regarding this embodiment, only the construction different from that of the first embodiment will be explained.

In this sheet supply apparatus, a belt separation portion **335** includes a separation belt **331** which extends between and wound around rollers **332**, **333**. The separation belt **331** is driven by a motor **M2** to rotate in a direction shown by the arrow B. The convey belt **14** is supported by the rollers **16**, **17** and **18** with a predetermined tension. The roller **17** is a drive roller which is driven by a motor **M1**. The convey belt **14** is intermittently driven by the drive roller **17** in a direction shown by the arrow A to convey the sheet S. A double-feed detection sensor **334** is arranged in the proximity of the separation belt **331**.

Next, the operation of this sheet supply apparatus will be explained.

First of all, the valve **22** is switched to the position a by the switch means (not shown) such as a solenoid so that the blower **21** is operated to direct the air from the nozzles **19** toward the tip end of the sheet stack S. As a result, several sheets **S1**, **S2** are blown up to float. Then, the valve **13** is switched to the position c by the switch means such as a solenoid so that the blower **12** is operated to suck the air through the absorb openings **6**, **10** and the air openings **14A**. As a result, the uppermost sheet **S1** is absorbed to the first and second sheet absorb means **4**, **8** and is closely adhered to the sheet absorb surfaces **14H-1**, **14H-2** of the convey belt **14**.

More specifically, the central portion of the sheet **S1** is absorbed to the first sheet absorb means **4** and the tip end portion of the sheet S1 is absorbed to the second sheet absorb means **8**. In this case, since the absorbing forces of the first and second sheet absorb means **4**, **8** are set to be sufficiently strong, the sheet S1 is bent around the displacement fulcrum portion **15A** in opposition to the resilience of the sheet, with the result that the tip end portion and the central portion of the sheet S1 are closely contacted with the sheet absorb surfaces **14H-1**, **14H-2** of the convey belt **14**, respectively. That is to say, the sheet **S1** follows the sheet absorb surfaces **14H-1**, **14H-2** to become convex downwardly around the displacement fulcrum portion **15A**.

In this case, if the second sheet S2 is closely contacted with the first sheet S1, although the central portion of the sheet S2 substantially follows the sheet S1, since the surface of the second sheet absorb means **8** is covered by the first sheet S1, the tip end portion of the sheet S2 is not subjected to the absorbing force. Accordingly, since the resilience of the second sheet S2 overcomes the absorbing force, the second sheet S2 is not bent around the displacement fulcrum portion **15A** to maintain the flat attitude, with the result that the tip end of the second sheet S2 is separated from the tip end of the first sheet S1, thereby creating the gap e between the sheets.

Thereafter, the valve **22** is switched to the position b to stop the injection of the air for floating the sheet S and to stop the blower **21**. As a result, the second sheet S2 drops on the tray **1** by its own weight. At the same time, the convey belt **14** is driven by the motor **M1** to convey the sheet S1 in the direction shown by the arrow A. Accordingly, only the sheet S1 is conveyed toward the downstream direction to be sent to the paired convey rollers **23**.

In this embodiment, while an example that when the injection of the air from the nozzles **19** is stopped the sheet S2 drops by its own weight was explained, it is feared that the second sheet S2 is also conveyed together with the first sheet S1 because these sheets are closely contacted with each other, depending upon the kinds of the sheets and/or due to the poor cutting of the sheet edges and the charging of the sheets. In this case, although the sheet S1 is conveyed in the direction shown by the arrow A while closely contacting with the convey belt **14**, the second sheet S2 is dragged by the sheet S1 to abut against the separation belt **331**. This condition is shown in FIG. **26**. The sheet S2 is further dragged to reach the double-feed detection sensor **334**. When the tip end of the sheet S2 is detected by the double-feed detection sensor **334**, the motor N2 is operated to drive the separation belt **331** in the direction shown by the arrow B. As a result, the sheet S2 is returned onto the tray **1** by the friction force of the separation belt **331**. The separation belt **331** is stopped when a predetermined time period is elapsed.

In this way, even if the sheets are double-fed, the sheets can be separated without fail by the action of the separation belt **331**.

In this embodiment, while the separation belt 331 was driven on the basis of the detection of the double-feed detection sensor 334, the separation belt 331 may always be driven when the convey belt 14 is being driven.

FIG. 27 shows a whole construction of a sheet supply apparatus according to a sixteenth embodiment of the present invention.

In this sheet supply apparatus, a second sheet absorb means 350 is arranged at a downstream side of the first sheet absorb means 4 in the sheet convey direction. Further, the second sheet absorb means 350 comprises a hollow absorb roller 351 having a plurality of absorb openings 351A formed in the surface thereof, a suction chamber portion 352, and a cover 353 for covering the absorb roller 351 except for a portion thereof for absorbing the sheet S. Since the sheet absorbing portion (surface) of the absorb roller 351 has a curvature, it is positioned substantially above the flat bottom plate 5 of the first sheet absorb means 4.

The first sheet absorb means 4 and the second sheet absorb means 350 are connected to the blower 12. The convey belt 14 is mounted in such a manner that it covers the surfaces of the first and second sheet absorb means 4, 350. The convey belt 14 is supported by the rollers 15, 16, 17 and 18 with a predetermined tension and is intermittently driven in the direction shown by the arrow A by the motor M1, thereby conveying the sheet. A belt separation portion 335 is opposed to the second sheet absorb means 350 at the downstream side of the tray 1 in the sheet convey direction. The construction of the belt separation portion 335 is the same as that of the above-mentioned fifteenth embodiment.

Also in this sheet supply apparatus having the construction as mentioned above, by adopting the same operation as that of the above-mentioned fifteenth embodiment, it is possible to return the double-fed sheet S2 onto the tray 1.

FIG. 28 shows a whole construction of a sheet supply apparatus according to a seventeenth embodiment of the present invention. In this embodiment, a belt separation portion is applied to the conventional air sheet supply apparatus.

In this sheet supply apparatus, the convey belt 14 is supported by rollers 340, 16, 17 and 18 with a predetermined tension. The roller 17 is a drive roller which is driven by the motor M1. The convey belt 14 is intermittently driven by the drive roller 17 in the direction shown by the arrow A, thereby conveying the sheet S.

A belt separation portion 335 includes a separation belt 331 which extends between and wound around rollers 332, 333. The separation belt 331 is driven by the motor M2 in the direction shown by the arrow B. A double-feed detection sensor 334 is arranged in the proximity of the separation belt 331.

Next, the operation of this sheet supply apparatus will be explained.

The operation of this sheet supply apparatus is the same as that of the apparatus according to the above-mentioned fifteenth embodiment. That is to say, if the second sheet S2 is conveyed together with the first sheet S1, the sheet S1 is conveyed in the direction shown by the arrow A while closely contacting with the convey belt 14, and the sheet S2 is dragged by the sheet S1. The tip end of the sheet S2 comes down by its own weight and is abutted against the separation belt 331. The sheet S2 is further dragged to reach the double-feed detection sensor 334. When the tip end of the sheet S2 is detected by the double-feed detection sensor 334, the motor M2 is operated to shift the separation belt 331 in the direction shown by the arrow B.

As a result, the sheet S2 is returned onto the tray 1 by the friction force of the separation belt 331. The separation belt 331 is stopped when a predetermined time period is elapsed. In this way, even if the sheets are double-fed, the sheets can be separated without fail by the action of the separation belt 331.

In this embodiment, while the separation belt 331 was driven on the basis of the detection of the double-feed detection sensor 334, the separation belt 331 may be always driven when the convey belt 14 is being driven.

Next, an eighteenth embodiment in which an area of the absorb opening of the sheet absorb means is controlled regarding the first embodiment will be explained.

In this eighteenth embodiment, the area of the absorb opening of the first sheet absorb means 4 of the first embodiment is controlled. Thus, this control will be fully explained.

FIGS. 29A and 29B are views of the sheet convey portion 3 looked at from the downstream side of the sheet convey direction, and FIGS. 30A and 30B are views of the sheet convey portion 3 looked at from the bottom. As shown in FIG. 31, a shutter sheet (shutter member) 435*a* has a small opening portion 436*a* (having a width substantially the same as that of a small size sheet SS) corresponding to the small size sheet SS, and a large opening portion 436*b* (having a width substantially the same as that of a large size sheet SL) corresponding to the large size sheet SL. The shutter 435*a* constitutes an air absorb opening portion and is secured to rotatably supported shafts 437, 438 at its both ends and is wound around the shafts. Motors (drive means) M1, M2 serve to rotatingly drive the shafts 437, 438 to wind up the shutter 435*a*.

With this arrangement, when the small size sheet SS is supplied, the motor M1 is driven to wind up the shutter 435*a* in a direction shown by the arrow (right in FIG. 30A), with the result that the sheet SS is absorbed with the opening portion 436*a* maintained in a condition shown in FIG. 30A. Accordingly, as shown in FIG. 29A, since the opening portion 436*a* is generally covered by the sheet SS, the leakage of air is prevented, thus obtaining the sufficient absorbing force. On the other hand, when the large size sheet SL is supplied, the motor M2 is driven to wind up the shutter 435*a* in a direction shown by the arrow (left in FIG. 30B), with the result that the sheet SL is absorbed with the opening portion 436*b* maintained in a condition shown in FIG. 30B. Accordingly, as shown in FIG. 29B, since the sheet SL is absorbed through its whole length, both ends of the sheet SL are also adhered to the convey belt 14.

Next, a nineteenth embodiment of the present invention will be explained with reference to FIGS. 32A, 32B and 33. Incidentally, since the fundamental construction of a sheet supply apparatus of this embodiment is substantially the same as that of the eighteenth embodiment, the same constructural elements as those of the eighteenth embodiment are designated by the same reference numerals and the detailed explanation thereof will be omitted. As shown in FIG. 33, the sheet supply apparatus according to the nineteenth embodiment has a shutter sheet (shutter member) 435*b*. The shutter sheet 435*b* has a group of openings A' corresponding to a small size sheet SS and including three opening portions 436*c*, and a group of openings B7 corresponding to a large size sheet SL and including four opening portions 436*c*. As similar to the eighteenth embodiment, the opening group A' is arranged as shown in FIG. 32A to absorb the sheet SS. On the other hand, when the large size sheet SL is supplied, the opening group B' is arranged as shown in

FIG. 32B to absorb the sheet SL.

In this example, while the number of opening portions corresponding to the small size sheet SS was decreased and the number of the opening portions or the distance between the opening portions corresponding to the large size sheet SL was increased, such number of openings and/or the opening-to-opening distance may be varied.

Next, a twentieth embodiment of the present invention in which the injection of airs from the nozzles **19, 20** regarding the first embodiment is controlled will be explained.

Since the construction of a sheet supply apparatus itself of the twentieth embodiment is the same as that of the first embodiment (only the air injection controls are different from each other), the apparatus itself is not shown.

When the sheet S is floated, the valve **22** is switched to the position a to inject the air from the nozzles **19**, and when the sheets S are separated, the valve **22** is switched to the position b to inject the air from the nozzles **20**. In this way, the sheet supply operation is effected.

By the way, when the sheet supply operation of the sheet supply apparatus is not performed, the valve **22** is switched to the position a so that the nozzles **19** are controlled by a control portion (adjust means) (not shown) in such a manner that an air amount injected from the nozzles **19** in the sheet supply operation is reduced. Also in this condition, several sheets S can be blown up to float, and the air can be introduced between the floated sheets. The other constructions of this sheet supply apparatus is the same as those of the first embodiment.

FIG. **34** shows a detailed drive timing chart. The blower **12** is not rotated when the sheet supply operation is not effected; but, during the sheet supply operation, the blower **12** is rotated. When the sheet supply operation is finished, the blower **12** is stopped. In this case, the blower **21** is rotated with the smaller number (P1) of rotation when the sheet supply operation is not effected, and is rotated with the number P2 (>P1) of rotation during the sheet supply operation. When the sheet supply operation is finished, the number of rotation of the blower **21** is returned from P2 to P1. Further, when the sheet supply operation is not effected, the valve **13** is in the position d; but, the valve **13** is switched to the position c in the sheet supply operation, and is returned to the position d when the sheet supply operation is finished. On the other hand, the valve **22** is in the position a when the sheet supply operation is not effected; but, the valve **22** is switched to the position b in the sheet supply operation, and is returned to the position a when the sheet supply operation is finished. Further, the drive of the convey belt **14** is turned OFF when the sheet supply operation is not effected; but, when the sheet supply operation is started and the sheet S has been adhered to the convey belt **14**, the drive of the convey belt **14** is turned ON to convey the sheet S, and when the sheet supply operation is finished the drive of the convey belt **14** is turned OFF again. By controlling the blower **21** and the valve **22** as mentioned above, the blow amount of the nozzle **19** becomes as shown in FIG. **34** so that, when the sheet supply operation is not effected, the air is injected with the blow amount Q2 smaller than the blow amount Q1 (during the sheet supply operation).

In this way, when the sheet supply operation is not effected, by injecting the air against the sheet stack S, since it is possible to float several sheets and to pass the air along both surfaces of each sheet, thereby reducing the moisture absorption of the sheet and making the hygroscopicity of the sheets uniform, it is possible to perform the excellent image formation without any image flow and the curl in the sheet S.

Further, particularly in this embodiment, since the air blowing means for reducing the moisture absorption of the sheet and for making the hygroscopicity of the sheets uniform also serves as the air blowing means (blower **21** and nozzle **19**) for floating the sheets in the sheet supply apparatus, the sheet supply apparatus is prevented from making large-sized and expensive.

Furthermore, in this embodiment, while the blow amount from the nozzle **19** in the non-sheet supply period was smaller than the blow amount in the sheet supply operation to reduce the noise, the blow amount in the non-sheet supply period may be equal to the blow amount in the sheet supply operation, or, when the sheet supply apparatus is used under the high humidity condition, the blow amount in the non-sheet supply period may be greater than the blow amount in the sheet supply operation to further reduce the moisture absorption of the sheet S and to make the hygroscopicity of the sheets further uniform.

Further, as shown in FIG. **35**, the arrangement of the elements of the sheet supply apparatus may be inverted (upside down) with respect to the arrangement of FIG. **1**. With this arrangement, the sheets S are separated and conveyed one by one from a lowermost sheet of the sheet stack. Such arrangement is mainly used in an automatic original feeding apparatus of various image forming apparatuses (particularly, copying machines) or in a sheet tray of a sheet reversing (inverting) portion of both-sided image forming apparatuses. By injecting the air in the non-sheet supply period, since it is possible to pass the air along both surfaces of stacked sheets, the moisture absorption of the sheet S can be reduced and the hygroscopicity of the sheets can be made uniform, thereby performing the excellent image formation without any image flow and the curl in the sheet S.

Further, in the twentieth embodiment, while an example that the present invention is applied to the sheet supply apparatus was explained, the present invention is not limited to this example, but the air blowing means may be provided in a roller sheet supply apparatus, for example. Accordingly, the kind of the sheet supply apparatus is not limited. Furthermore, in this embodiment, while the air was always injected from the nozzles even in the non-sheet supply period, for example, in order to save the electric power and to reduce the noise, a means for manually turning OFF the air injection when the image forming apparatus is not used for a long time may be provided.

Next, a twenty-first embodiment of the present invention will be explained with reference to FIGS. **36A** to **36C**. Incidentally, since the fundamental construction of a sheet supply apparatus according to the twenty-first embodiment is substantially the same as that of the twentieth embodiment, the same constructural elements are designated by the same reference numerals and the explanation thereof will be omitted. FIGS. **36A** to **36C** are sectional views showing the variable condition of the valve **22** of the air blowing means.

In accordance with the kinds of the sheets S, the operator manipulates a switch means (not shown) exposed from the sheet supply apparatus. For example, when the kinds of the sheets S are grouped into three (thick sheet, thin sheet and normal sheet), the operator can shift the switch means to one of three positions corresponding to three kinds of sheets. In response to the shifting movement of the switch means, a regulating valve (adjust means) **22***a* is shifted along a plane including the lower openings of the nozzles **19, 20** to control the opening areas of the nozzles **19, 20**.

FIGS. 36A to 36C show schematic positional relation of the regulating valve 22a between the above-mentioned three kinds of sheets. FIG. 36A shows a condition that the thick sheet is handled. In this case, the regulating valve is adjusted so that the blow amount from the nozzle 19 becomes greater than the blow amount from the nozzle 20 (f>g), thereby increasing the floating force for floating the sheets S. FIG. 36B shows a condition that the thick sheet is handled. In this case, the regulating valve is adjusted so that the blow amount from the nozzle 19 becomes smaller than the blow amount from the nozzle 20 (f<g), thereby decreasing the floating force for floating the sheets S to enhance the separating ability. FIG. 36C shows a condition that the normal sheet is handled. In this case, the regulating valve 22a is adjusted so that the opening area of the nozzle 19 becomes substantially the same as that of the nozzle 20 (f=g). That is to say, the regulating valve 22a is shifted to control the air amounts from the nozzles 19, 20 so that the sum of the air amount from the nozzle 19 and the air amount from the nozzle 20 is always constant, thereby supplying the air amounts in accordance with the property of the sheet.

When the regulating valve 22a is fixed on the basis of the above-mentioned positional relation, then, the valve 22 is switched to the position a by the switch means (not shown) such as a solenoid so that the blower 21 is operated inject the air from the nozzle 19 toward the tip end of the sheet stack S. As a result, several sheets S are blown up to float. Then, the valve 13 is switched to the position c by the switch means (not shown) such as a solenoid so that the blower 12 is operated to suck the air through the absorb openings 6, 10 and the air openings 14a. In this way, the uppermost sheet S1 is absorbed to the first and second sheet absorb means 4, 8 and is closely contacted with the convey belt 14.

Next, a twenty-second embodiment of the present invention will be explained with reference to FIG. 37. Incidentally, since the fundamental construction of a sheet supply apparatus according to the twenty-second embodiment is substantially the same as that of the twentieth embodiment, the same constructural elements are designated by the same reference numerals and the explanation thereof will be omitted.

FIG. 37 is a sectional view showing the air blowing means. In the twenty-first embodiment, while the regulating valve 22a was slidingly shifted to regulate the opening areas of the nozzles 19, 20, in this twenty-second embodiment, the regulating valve 22a is of rotatable type in which the rotation angle of the regulating valve is changed in accordance with the kinds of the sheets to regulate the opening areas of the nozzles 19, 20. That is to say, when the thick sheet is handled, a wall 23a protruded from the regulating valve 22a is brought into a position h, where the opening areas of the nozzles are regulated so that the opening area of the nozzle 19 becomes greater than the opening area of the nozzle 20. Further, when the thin sheet is handled, the wall is brought into a position j (opposite to the position h), where the opening area of the nozzle 19 becomes smaller than the opening area of the nozzle 20. Further, when the normal sheet is handled, the wall is brought into a position i, where the opening area of the nozzle 19 becomes substantially the same as the opening area of the nozzle 20.

Next, a twenty-third embodiment of the present invention will be explained with reference to FIG. 38. Incidentally, since the fundamental construction of a sheet supply apparatus according to the twenty-third embodiment is substantially the same as that of the twentieth embodiment, the same constructural elements are designated by the same reference numerals and the explanation thereof will be omitted.

FIG. 38 is a sectional view showing the air blowing means. In this embodiment, the valve 22 and the regulating valve 22a are not used, but air blowing blowers 21 having the same ability are attached to the nozzles 19, 20, respectively. These blowers 21 are set so that a service voltage is proportional to the number of rotation of the blower 21 (i.e., air amount injected from the blower). By an electric means (not shown) for changing the voltages V1, V2 (V1+V2=V) supplied to the blowers 21 relatively, when the thick sheet is handled, a relation V1>V2 is established, and, when the thin sheet is handled, a relation V1<V2 is established, and when the normal sheet is handled, a relation V1=V2 is established. In this way, the air amounts injected from the nozzles 19, 20 are regulated relatively, thereby achieving the same technical effect as that of the twenty-second embodiment.

Next, a twenty-fourth embodiment of the present invention will be explained with reference to FIGS. 39 to 41. Incidentally, in this twenty-fourth embodiment, a detection means for detecting the resilience of the sheet is provided in the sheet supply apparatus of the first embodiment. Further, since the fundamental construction of a sheet supply apparatus according to the twenty-third embodiment is substantially the same as that of the first embodiment, the same constructural elements are designated by the same reference numerals and the explanation thereof will be omitted. FIG. 39 is a sectional view of the sheet supply apparatus, FIG. 40 shows a condition that a (thin) sheet having the weak resilience is supplied by the sheet supply apparatus, and FIG. 41 shows a condition that a (thick) sheet having the strong resilience is supplied by the sheet supply apparatus.

A detection projection (detection means) 530 is arranged at an upstream side of the first sheet absorb means 4 in the sheet convey direction and is disposed above the sheet stack S rested on the sheet stacking tray 1 to protrude downwardly from the flat bottom plate 5 of the first sheet absorb means toward the sheet stacking tray 1. The detection projection 530 is movable to a direction shown by the arrow B in FIG. 39. Photo-sensors (detection means) 531, 532 for detecting the position of the detection projection 530 are provided, so that ON and OFF are switched by the shifting movement of the detection projection 530 in an up-and-down direction. These photo-sensors are used when various conditions regarding the sheet supply operation and/or the transfer operation are set by the operator or a service man. First of all, when the sheet S is not absorbed to the first sheet absorb means 4, the condition shown in FIG. 39 is maintained, where both of the photo-sensors 531 and 532 are in an ON condition.

Then, by depressing a set start switch (not shown), the sheet S is absorbed to the first sheet absorb means 4 as mentioned above. In this case, a trailing end portion of the sheet S positioned at the upstream side of the first sheet absorb means 4 in the sheet convey direction is not absorbed to the first sheet absorb means 4 and is subjected to an upwardly directing force tending to follow the sheet along the flat bottom plate of the first sheet absorb means 4 due to the resilience of the sheet S. However, since the trailing end portion of the sheet is pushed downwardly by a force tending to dropping the detection projection 530, the trailing end portion of the sheet S is stopped at a position where these two forces are balanced. In case of the (thin) sheet having the weak resilience, since the detection projection 530 is stopped at a position A1 in FIG. 40, the photo-sensor 531 is turned OFF by the detection projection 530. As a result, "weak resilience" (thin sheet) is displayed on a display means 533. In case of the (thick) sheet having the strong resilience, since the detection projection 530 is stopped at a

position A2 in FIG. 41, the photo-sensor 532 as well as the photo-sensor 531 are turned OFF. As a result, "strong resilience" (thick sheet) is displayed on the display means 533.

Thus, when the resilience of the sheet S is varied depending upon the kind of the sheet, the position where the above-mentioned two forces are balanced is also varied (that is to say, the position to which the detection projection 530 is shifted is varied). By measuring the shifting amount of the detection projection 530, it is possible to detect the resilience of the sheet S. By checking the detection result by means of the display means, the operator or the service man can understand the resilience of the sheet S and can set the optimum conditions regarding the transfer voltage, the air absorbing force in the sheet supply operation, the fixing temperature and the like.

Next, further embodiments of the present invention regarding the air absorb opening of the sheet absorb means 4 in the first embodiment will be explained.

Incidentally, since the fundamental construction of one of the further embodiments (twenty-fifth embodiment) is the same as that of the first embodiment, the detailed explanation thereof will be omitted, but only the characteristic portion will be fully explained with reference to FIG. 42 which is a bottom view of the sheet absorb means showing the characteristic of the twenty-fifth embodiment clearly.

In the conventional sheet supply apparatus, while air openings 6*a* formed in the flat bottom plate 5 of the air suction chamber 7 provided in the sheet convey portion 3 had same diameter, in this twenty-fifth embodiment, such air openings 6*a* are so arranged that the area of each air opening disposed nearest to the air sucking blower 12 is minimum and the area of each air opening disposed farthest from the air sucking blower 12 is maximum and the areas of the air openings are gradually increased as the openings go away from the air sucking blower 12.

In FIG. 42, the air suction chamber 7 is covered by a plurality of identical convey belts 14, and is communicated with the air sucking blower 12 at one end of the chamber (in a direction perpendicular to the sheet convey direction, i.e., a widthwise direction of the sheet), so that the air sucked from the air suction chamber 7 flows along a direction substantially perpendicular to the sheet convey direction.

Further, a plural rows (along the sheet convey direction) of air openings 6*a* having different opening areas are formed in the flat bottom plate 5 defining the suction chamber 7 at positions corresponding to the positions of the rows of the air openings 14A formed in the respective convey belts 14 in such a manner that the diameters of the air openings 6*a* in each row are identical and the areas of the air openings 6*a* are gradually increased as the air openings go away from the air sucking blower 12. That is to say, the opening areas of the air openings are selected so that, when the opening area of each air opening 6*a* nearest to the air sucking blower 12 is S1, the opening area of each air opening adjacent to the aforementioned one is S2 and so on, a relation $S1<S2<S3<S4<S5<S6< \ldots <Sn$ is established, and the air sucking pressure loss of each air opening is identical to each other.

The air sheet supply apparatus having the air suction chamber 7 with the above-mentioned arrangement is operated as follows. The air injection belower 21 is operated by a predetermined manipulation so that the air from the floating nozzle 19 is injected against the tip end of the sheet stack, thereby blowing up several sheets S to float. Then, the suction valve 13 is switched by the switch means (not shown) such as a solenoid from a position d shown by the broken line to a position c shown by the solid line so that the air sucking blower 12 is operated to suck the sheet S through the air openings 6*a*, 14A, thereby adhering the sheet S to the convey belts 14.

In this case, even when the sheet S to be conveyed is thickest, since the absorbing force of each convey belt 14 along the sheet convey direction is substantially constant, the sheet is not skew-fed and the end of the sheet is not depended down, with the result that only the uppermost sheet is surely adhered to the convey belts 14 closely by the positive separation action of the separating nozzle 20 and the sheet is surely conveyed in the downstream direction by the rotations of the rollers 15, 16, 17, 18.

Incidentally, in the above embodiment, while the air openings were circular, for example, a plural rows of air openings in the form of a trapezoid contacting with the circles S1 and S2, a trapezoid contacting with the circles S3 and S4 and a trapezoid contacting with the circles S5 and S6 respectively and having gradually increased opening areas, or integral air openings in the form of a trapezoid contacting with the circles S1 and S6 may be formed in the flat bottom plate.

Next, a twenty-sixth embodiment of the present invention will be explained. The same constructural elements as those of the twenty-fifth embodiment are designated by the same reference numerals and the explanation thereof will be omitted. FIG. 43 shows the twenty-sixth embodiment and is a bottom view of a sheet convey means to which the present invention is applied.

In the fifteenth embodiment, while the air sucking blower 12 was connected to one end of the air suction chamber 7 in the direction perpendicular to the sheet convey direction, in the twenty-sixth embodiment, as shown in FIG. 43, the air sucking blower 12 is connected to a central portion of one surface (facing the sheet convey direction) of the air suction chamber 7, and air openings 6*b* are arranged so that the opening areas of the air openings are gradually increased from a central portion (nearest to the blower 12) of the chamber to both ends of the chamber. In this way, the same technical effect as that of the fifteenth embodiment can be obtained.

FIG. 44 shows the twenty-seventh embodiment and is a bottom view of a sheet convey means to which the present invention is applied.

In the twenty-fifth embodiment, while the air openings 6*a* having the different opening areas were formed in the flat bottom plate 5 defining the air suction chamber 7, in the twenty-seventh embodiment, as shown in FIG. 44, although the air openings 6*a* having the same opening area are formed in the same manner as the conventional case in correspondence to the width of each convey belt 14, a plurality of air openings 14B formed in the convey belts 14 are arranged so that, as in the twenty-second embodiment, the opening areas of the air openings 14B are gradually increased as the air openings go away from the air sucking blower 12.

Next, a twenty-eighth embodiment of the present invention in which a means for reducing the moisture absorption of the sheet is provided in the apparatus of the first embodiment will be explained.

In FIG. 45, a heater 550 is arranged between the blower 21 and the nozzles 19, 20. A temperature sensor 551 for detecting the temperature of the proximity of the sheet stack S is arranged in the vicinity of the sheet stacking tray 1. The heater 550 is appropriately controlled by a control means 552 on the basis of the detection result of the temperature

sensor 551.

Next, the operation of the apparatus according to the twenty-eighth embodiment will be described.

Both when the sheet supply operation of the sheet supply apparatus is effected and when the sheet supply operation is not effected, the heater 550 is always driven to generate heat. Accordingly, the hot air always flows along the surfaces of several sheets on the sheet stack.

FIG. 46 is a detailed drive timing chart regarding this embodiment. When the sheet supply operation is not effected, the blower 12 is not rotated; however, when the sheet supply operation is started the blower is rotated and when the sheet supply operation is finished the blower is stopped. When the sheet supply operation is not effected, the blower 21 is being rotated at the number p1 of rotation which is smaller than the number of rotation in the sheet supply operation, and when the sheet supply operation is started the blower is rotated at the number p2 (>p1) of rotation, and when the sheet supply operation is finished the number of rotation of the blower is returned to p1.

When the sheet supply operation is not effected, the valve 13 is in the position d; but, when the sheet supply operation is effected, the valve 13 is switched to the position c, and, immediately before the sheet supply operation is finished, the valve is returned to the position d. When the sheet supply operation is not effected, the valve 22 is in the position a; but, when the sheet supply operation is effected, the valve 22 is switched to the position b, and, immediately before the sheet supply operation is finished, the valve is returned to the position a.

When the sheet supply operation is not effected, the drive of the convey belt 14 is in the OFF condition; but, when the sheet supply operation is started and the sheet has been adhered to the convey belt 14, the drive of the convey belt is turned ON to convey the sheet. By controlling the blower 21 and the valve 22 as mentioned above, the blow amount of the nozzle 19 becomes as shown in FIG. 46 so that, when the sheet supply operation is not effected, the air is injected with the blow amount q2 smaller than the blow amount q1 (during the sheet supply operation). The heater 550 is turned ON both when the sheet supply operation is being effected and when the sheet supply operation is stopped.

In this way, even when the sheet supply operation is not effected, by sending the hot air to the several sheets, since it is possible to float the several sheets and to pass the hot air along both surfaces of each sheet, thereby reducing the moisture absorption of the sheet and making the hygroscopicity of the sheets uniform, it is possible to perform the excellent image formation without any image flow and the curl in the sheet S.

Further, particularly in this embodiment, since the air sheet supply apparatus is used as the sheet supply apparatus and the air blowing means for reducing the moisture absorption of the sheet and for making the hygroscopicity of the sheets uniform also serves as the air blowing means (blower 21 and nozzle 19) for floating the sheets in the sheet supply apparatus, the sheet supply apparatus is prevented from making large-sized and expensive. Incidentally, in this embodiment, while the blow amount from the nozzle in the non-sheet supply period was smaller than the blow amount in the sheet supply operation to reduce the noise, the blow amount in the non-sheet supply period may be equal to the blow amount in the sheet supply operation, or, when the sheet supply apparatus is used under the high humidity condition, the blow amount in the non-sheet supply period may be greater than the blow amount in the sheet supply operation to further reduce the moisture absorption of the sheet S and to make the hygroscopicity of the sheets further uniform.

Further, while an example that the present invention is applied to the air sheet supply was explained, the present invention is not limited to this example, but the air blowing means may be provided in a roller sheet supply apparatus, for example. Accordingly, the kind of the sheet supply apparatus is not limited. Furthermore, in this embodiment, while the air was always injected from the nozzle 19 even in the non-sheet supply period, for example, in order to save the electric power and to reduce the noise, a means for manually turning OFF the air injection when the image forming apparatus is not used for a long time may be provided.

Next, a twenty-ninth embodiment of the present invention in which the arrangement of the blower 12 is changed with respect to the first embodiment will be explained.

Since the fundamental construction and the general function of this embodiment are the same as those of the first embodiment, the detailed explanation thereof will be omitted, but only the characteristic portion will be fully explained with reference to FIG. 47 which is a bottom view of the sheet convey means showing the characteristic of the twenty-ninth embodiment clearly. In FIG. 47, air sucking blowers 12 having the identical ability are connected to both ends of the air suction chamber (in a direction perpendicular to the sheet convey direction), so that the air sucked from the air suction chamber 7 flows from a center of the air suction chamber 7 to the both ends thereof as shown by the arrows B. Further, a plurality of air openings 6*a*, 6*b*, 6*c* are formed in the flat bottom plate 5 defining the air suction chamber 7 at positions corresponding to the positions of the air openings 14A formed in the respective convey belts 14. Particularly, the opening areas of the air openings are so selected that the absorbing forces of the air sucking blowers 12 at the air openings 6*a* and 6*c* are equal to each other and the air suction pressure losses at the air openings 6*a* and 6*b* are equal to each other.

For example, when distances between the air sucking blowers 12 positioned at both ends (in a direction perpendicular to the sheet convey direction) of the suction chamber and the air openings 6*a*, 6*c* are L1, L2, respectively, and the opening areas of the air openings 6*a*, 6*c* are S11, S12, respectively, the opening areas are adjusted independence upon the above-mentioned distances so that when L1=L2 a relation S11=S12 is established and when L1>L2 a relation S11>S12 is established and when L1<L2 a relation S11<S12 is established, thereby equalizing the sheet absorbing forces at both ends of the sheet (in a widthwise direction).

The air sheet supply apparatus having the sheet convey means with the above-mentioned arrangement is operated as follows.

As in the conventionl apparatus, the air injection blower 21 is operated by a predetermined manipulation so that the air from the floating nozzle 19 is injected against the tip end of the sheet stack, thereby blowing up several sheets S to float. Then, the suction valve 13 is switched by the switch means (not shown) such as a solenoid from a position d shown by the broken line to a position c shown by the solid line so that the air sucking blowers 12 are operated to suck the air through the air openings 6*a*, 6*b*, 6*c* and 14A, thereby adhering the sheet S to the convey belts 14.

In this case, even when the sheet S to be conveyed is thickest, since the absorbing forces to the convey belts 14 in the widthwise direction of the sheet are substantially the same, the sheet is not skew-fed and the end of the sheet S is not depended down, with the result that only the uppermost sheet is surely adhered to the convey belts 14 closely by the

positive separation action of the separating nozzle 20 and the sheet is surely conveyed in the downstream direction by the rotations of the rollers 15, 16, 17 and 18.

Lastly, a thirtieth embodiment of the present invention will be explained. The same constructural elements as those of the twenty-ninth embodiment are designated by the same reference numerals and the explanation thereof will be omitted. FIG. 48 shows the thirtieth embodiment and is a bottom view of the sheet convey means to which the present invention is applied.

In the twenty-ninth embodiment, while the air sucking blowers 12 were directly connected to both ends of the chamber 7 in the direction perpendicular to the sheet convey direction, in this embodiment, as shown in FIG. 48, one or more blower 12 is arranged within the central convey belt 14 and is connected to the air suction chamber 7 via ducts 12*a* connected to both ends of the chamber in the direction perpendicular to the sheet convey direction, thereby achieving the same technical effect as that of the twenty-ninth embodiment.

Incidentally, in FIG. 48, while the air sucking blower 12 was arranged within the central convey belt, it may be arranged outside of such convey belt.

What is claimed is:

1. A sheet supplying apparatus, comprising:

sheet support means for supporting a plurality of sheets;

sheet absorb means, arranged facing a surface of the sheets supported by said sheet support means, for absorbing a sheet of the plurality of sheets by air suction;

sheet feed means for feeding out the sheet absorbed by said sheet absorb means;

convey means disposed downstream of said sheet feed means for conveying the sheet fed out by said sheet feed means; and

control means for controlling said sheet feed means and said sheet absorb means so that, when the sheet fed out by said sheet feed means stops being fed prior to reaching said convey means, said sheet feed means feeds the sheet in a direction opposite to the sheet feed direction to return it to said sheet support means, and said sheet absorb means absorbs the sheet at least until the sheet is returned to said sheet support means.

2. A sheet supplying apparatus according to claim 1, wherein said sheet absorb means includes first absorb means and second absorb means, an absorb surface of said first absorb means being disposed substantially parallel to surfaces of the sheets supported by said sheet support means, and an absorb surface of said second absorb means being inclined relative to the sheet surfaces so that the absorb surface is further from the sheet surfaces as it extends downstream in a sheet feeding direction, whereby the sheets are separated one by one by utilizing a tip end of the sheet absorbed by said second absorb means.

3. A sheet supply apparatus according to claim 2, wherein said second sheet absorb means comprises a cylindrical member having a plurality of air absorb openings on an outer peripheral surface thereof.

4. A sheet feeding apparatus according to claim 1, further comprising detection means for detecting whether the sheet reaches said convey means, said control means effecting the controlling based on the detecting by said detection means.

5. A sheet supply apparatus according to claim 1, wherein said sheet absorb means absorbs an uppermost sheet of the sheets supported by said sheet support means.

6. A sheet supply apparatus according to claim 1, wherein said sheet absorb means absorbs a lowermost sheet of the sheets supported by said sheet support means.

7. A sheet supply apparatus according to claim 1, wherein said convey means comprises a rotatable convey belt mounted on rollers to cover a surface of said sheet absorb means, and said convey belt is provided with a plurality of air openings, so that when said sheet absorb means absorbs the air the sheet is absorbed through said air openings for conveying.

8. A sheet supply apparatus according to claim 1, further comprising air blowing means for blowing air against a tip end of the sheet absorbed to promote separation of the sheet absorbed to said sheet absorb means.

9. A sheet supplying apparatus, comprising:

sheet support means for supporting a plurality of sheets;

sheet absorb means arranged facing a sheet surface of the sheets supported by said sheet support means for absorbing a sheet by air suction;

sheet feeding means for feeding out the sheet absorbed by said sheet absorb means;

air blowing means blowing the air against a tip end of the sheet for floating the sheet from said sheet support means; and

heating means applying predetermined heat to said air blowing means for causing heated air to blow from said air blowing means.

10. A sheet supply apparatus according to claim 9, further comprising separation rotation means driven in a direction opposite to a drive direction of said sheet feeding means for separating the sheets fed out by said sheet feeding means one by one.

11. A sheet supply apparatus according to claim 10, wherein said separation rotation means has a separation belt spanned between rollers, and said separation belt is driven in synchronization with said sheet feeding means.

12. A sheet supply apparatus according to claim 10, further comprising double-feed detection means disposed in the proximity of said separation rotation means for detecting a double-feed of the sheets conveyed by said sheet feeding means, wherein said separation rotation means is driven when the double-feed is detected by said double-feed detection means.

13. A sheet supplying apparatus according to claim 9, further comprising moisture detection means disposed in proximity to said sheet support means for detecting moisture, said heating means being controlled based on the detection result of said moisture detection means to keep constant moisture at a point in proximity to the sheet.

14. A sheet supplying apparatus according to claim 9, wherein said sheet absorb means includes first absorb means and second absorb means, an absorb surface of said first absorb means being disposed substantially parallel to surfaces of the sheets supported by said sheet support means and an absorb surface of said second absorb means being inclined relative to the sheet surfaces so that the absorb surface is further from the sheet surfaces as it extends downstream in a sheet feeding direction, whereby the sheets are separated one by one by lifting a tip end of the sheet absorbed by said second absorb means.

15. A sheet supply apparatus, comprising:

sheet support means for supporting a plurality of sheets;

sheet absorb means for absorbing a sheet of the plurality of sheets supported by said sheet support means by air suction, said sheet absorb means including first absorb means and second absorb means, an absorb surface of said first absorb means being disposed facing surfaces of the sheets supported by said sheet support means and an absorb surface of said second absorb means being

inclined relative to the sheet surfaces so that the absorb surface is further from the sheet surfaces as it extends downstream in a sheet feeding direction;

sheet feeding means for feeding out the sheet absorbed by said sheet absorb means; and

angle adjust means for adjusting an inclined angle of said second sheet absorb means.

16. A sheet supply apparatus according to claim 15, wherein said angle adjust means decreases the inclined angle of said second sheet absorb means as the resilience of the sheet is increased.

17. A sheet supply apparatus according to claim 16, wherein said sheet feeding means has a rotatable convey belt spanned between rollers to cover sheet absorb surfaces of said first and second sheet absorb means, and said convey belt is provided with a plurality of air openings, so that when said sheet absorb means absorb the air the sheet is absorbed through said air openings.

18. An image forming apparatus, comprising:

sheet support means for supporting a plurality of sheets;

sheet absorb means arranged facing a surface of the sheets supported by said sheet support means for absorbing a sheet of the plurality of sheets by air suction;

sheet feed means for feeding out the sheet absorbed to said sheet absorb means;

convey means disposed downstream of said sheet feed means for conveying the sheet fed out by said sheet feed means;

control means for controlling said sheet feed means and said sheet absorb means so that, when the sheet fed out by said control means stops being fed prior to reaching said convey means, said sheet feed means feeds the sheet in a direction opposite to the sheet feed direction to return it to said sheet support means, and said sheet absorb means absorbs the sheet at least until the sheet is returned to said sheet support means; and

image forming means for forming an image on the sheet conveyed by said conveying means.

19. An image forming apparatus, comprising:

sheet support means for supporting a plurality of sheets;

sheet absorb means for absorbing a sheet of the plurality of sheets supported by said sheet support means by air suction, said sheet absorb means including first absorb means and second absorb means, an absorb surface of said first absorb means being disposed substantially parallel to surfaces of the sheets supported by said sheet support means and an absorb surface of said second absorb means being inclined relative to the sheet surfaces so that the absorb surface is further from the sheet surfaces as it extends downstream in a sheet feeding direction;

sheet feeding means for feeding out the sheet absorbed by said sheet absorb means;

angle adjust means for adjusting an inclined angle of said second sheet absorb means; and

an image forming means for forming an image on the sheet fed by said sheet feeding means.

20. A sheet supplying apparatus, comprising:

sheet support means for supporting a plurality of sheets thereon;

sheet absorb means arranged facing a sheet surface of the sheets supported by said sheet support means for absorbing a sheet by air suction;

sheet feeding means for feeding out the sheet absorbed to said sheet absorb means; and

shock apply means for applying a shock to the sheet absorbed by said sheet absorb means to separate the sheets.

21. A sheet supplying apparatus according to claim 20, wherein said shock apply means includes sheet pressure means for shockably applying pressure to the sheet absorbed by said first absorb means.

22. A sheet applying apparatus according to claim 21, wherein said sheet pressure means includes a solenoid and a pressure rod operated by the solenoid, for pressurizing an absorbed surface of the sheet shockably.

23. A sheet supplying apparatus according to claim 20, wherein said shock apply means is a sheet pressure vibration rod for applying vibration to an absorbed surface of the sheet.

24. A sheet supplying apparatus according to claim 20, wherein said sheet absorb means includes first absorb means and second absorb means, an absorb surface of said first absorb means being disposed substantially parallel to surfaces of the sheets supported by said sheet support means, and an absorb surface of said second absorb means being inclined relative to the sheet surfaces so that the absorb surface is further from the sheet surfaces as it extends downstream in a sheet feeding direction, whereby the sheets are separated one by one by lifting a tip end of the sheet absorbed by said second absorb means.

* * * * *

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United States Patent [19]

Jantsch et al.

[11] Patent Number: 5,344,133

[45] Date of Patent: Sep. 6, 1994

[54] **VACUUM BELT FEEDER HAVING A POSITIVE AIR PRESSURE SEPARATOR AND METHOD OF USING A VACUUM BELT FEEDER**

[75] Inventors: Gregory R. Jantsch, Macedon; James D. Shifley, Spencerport; Michael T. Dobbertin, Honeoye; Theophilus C. Wituszynski, Fairport; Larry J. Mortellaro, Batavia; Henry P. Mitchell, Jr., Rochester, all of N.Y.

[73] Assignee: Eastman Kodak Company, Rochester, N.Y.

[21] Appl. No.: 23,032

[22] Filed: Feb. 25, 1993

[51] Int. Cl.[5] B65H 3/12

[52] U.S. Cl. 271/94; 271/98; 271/104; 271/105; 271/164; 271/171

[58] Field of Search 271/97, 98, 104, 105, 271/106, 30.1, 160, 162, 164, 94, 171

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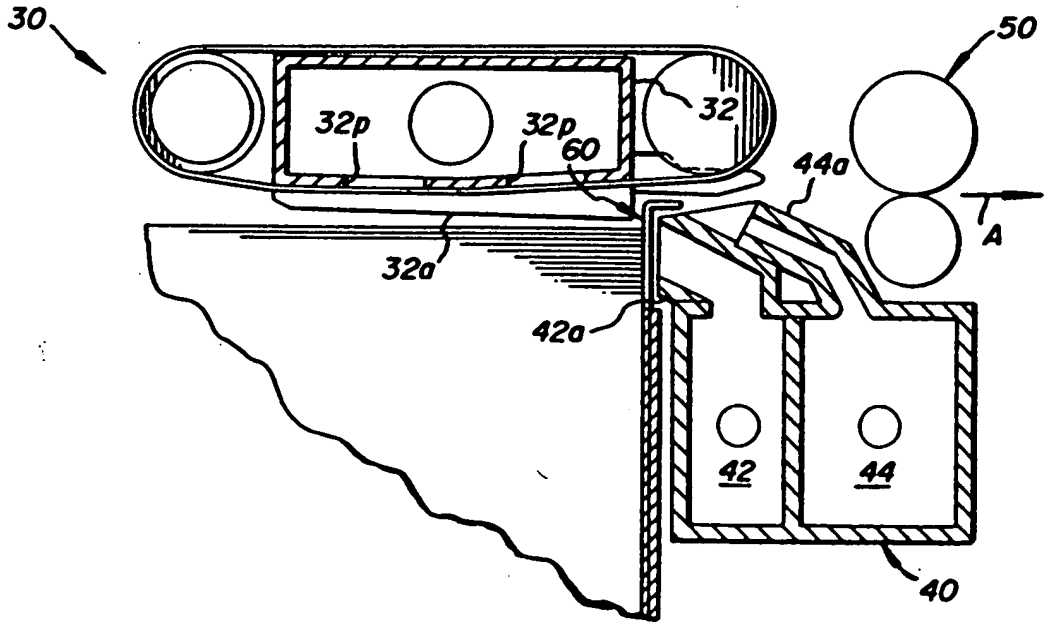
Primary Examiner—Robert P. Olszewski
Assistant Examiner—Boris Milef
Attorney, Agent, or Firm—Lawrence P. Kessler

[57] ABSTRACT

Apparatus for feeding sheets seriatim from a sheet supply stack. The apparatus comprises a sheet feed head assembly including a plenum, a vacuum source in flow communication with the plenum, and a mechanism, such as a feed belt, for example, associated with the plenum for urging a sheet acquired by vacuum in a sheet feeding direction away from the sheet supply stack. The sheet supply stack is supported, for example in a hopper on a support platform, so as to maintain the topmost sheet in such stack at a predetermined level in spaced relation with respect to the urging mechanism of the sheet feed head assembly. A first positive air supply directs a flow of air at the sheet supply stack to levitate the top several sheets in the supply stack to an elevation enabling the topmost sheet to be acquired by vacuum from the sheet feed head assembly plenum; and a second positive air supply directs a flow of air at an acquired sheet to assure separation of any additional sheets adhering to such topmost sheet.

28 Claims, 6 Drawing Sheets



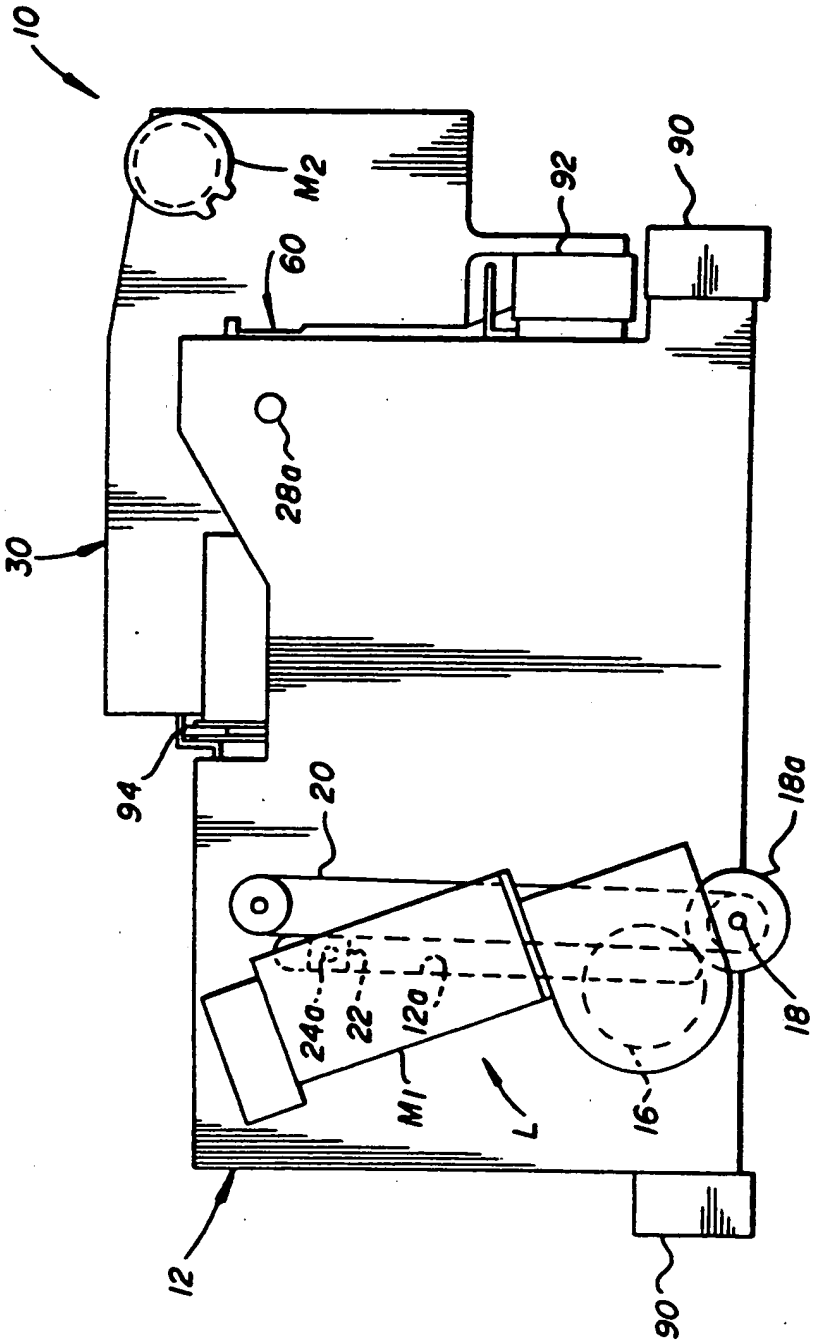
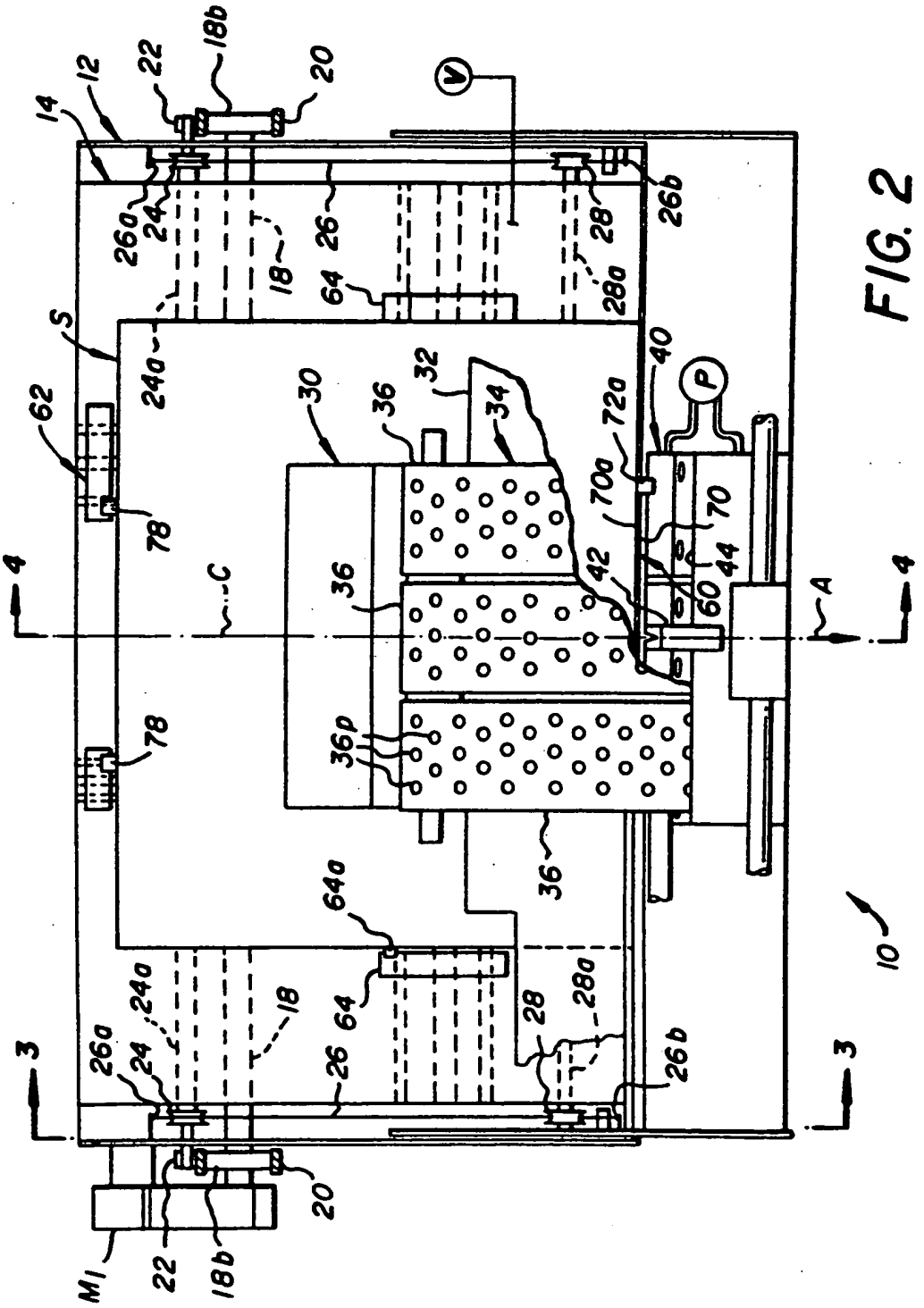


FIG. 1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C
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36p
36
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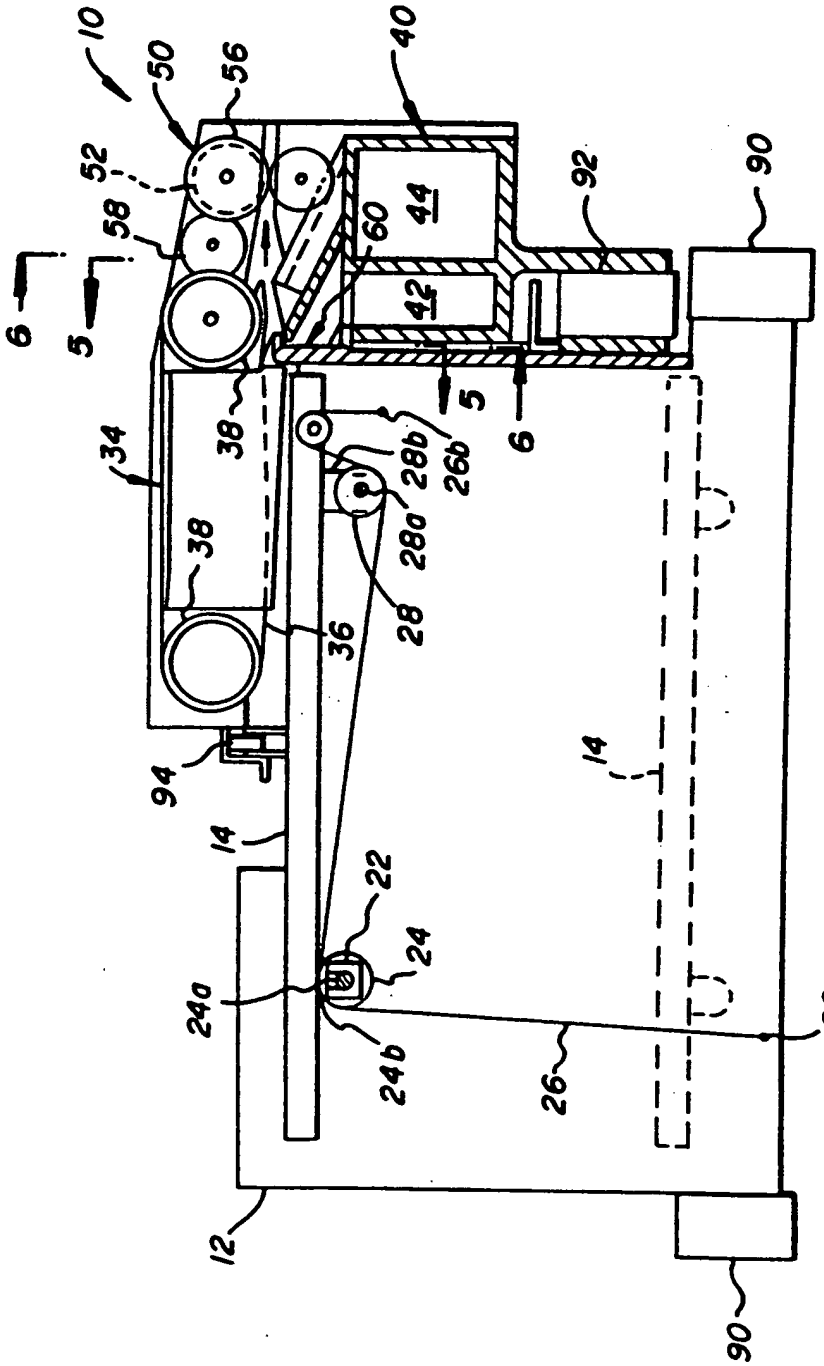
FIG. 2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90

FIG. 3

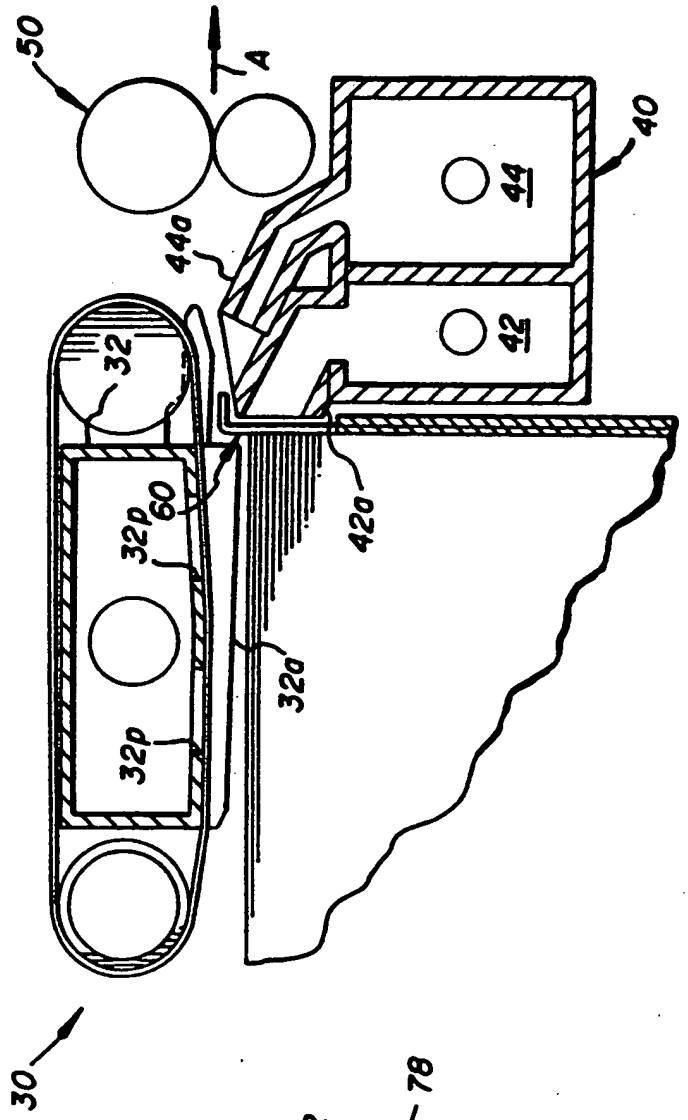


FIG. 4

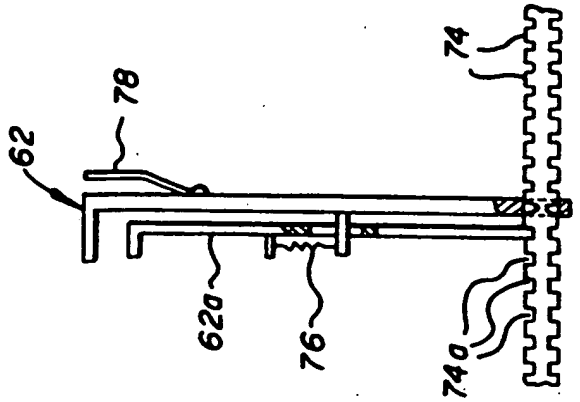
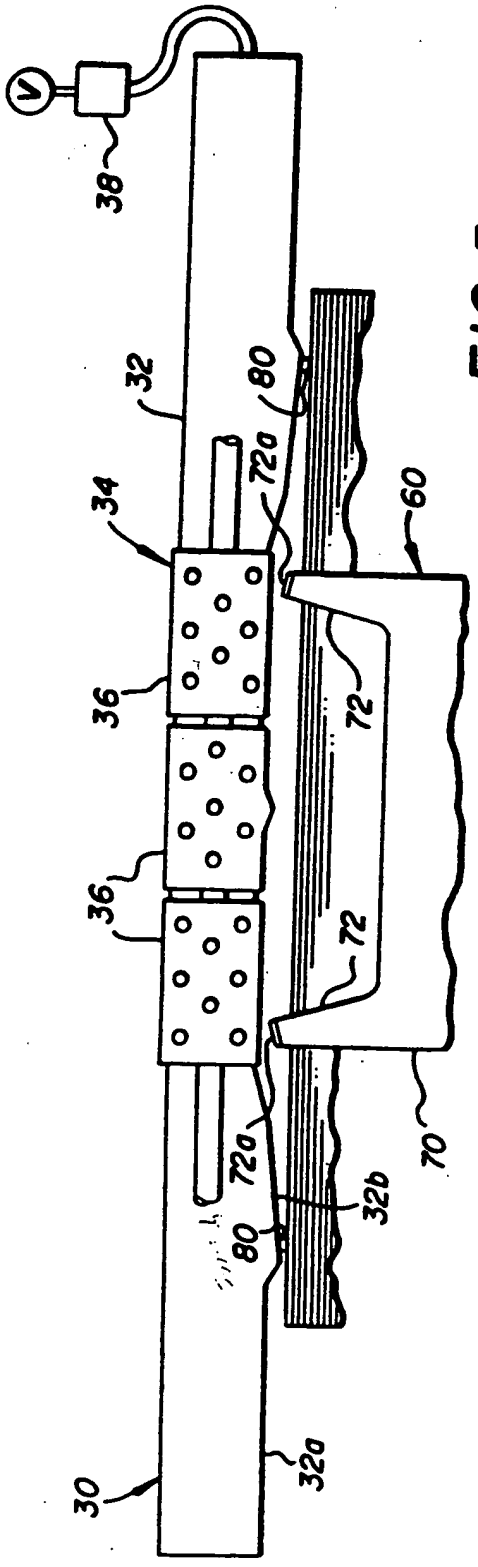


FIG. 8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72a
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80
70
32a
30

FIG. 5

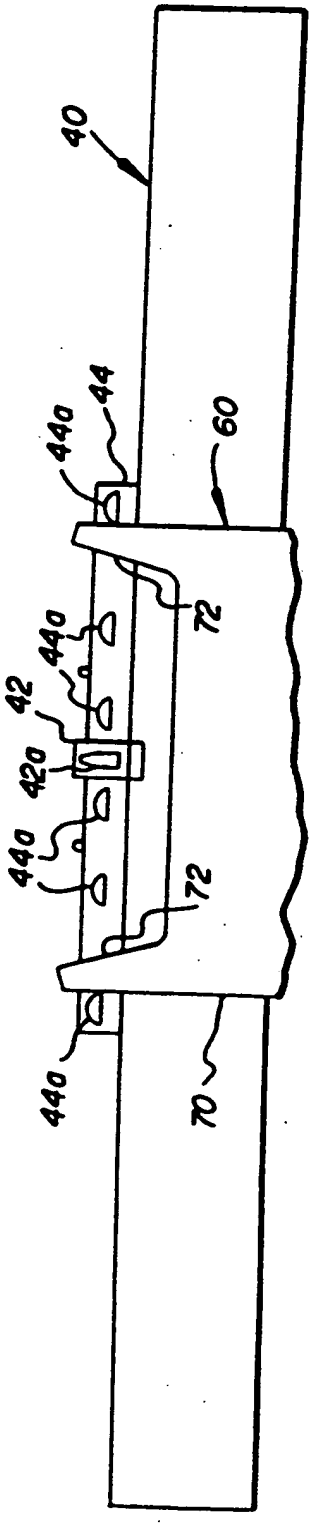
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FIG. 6

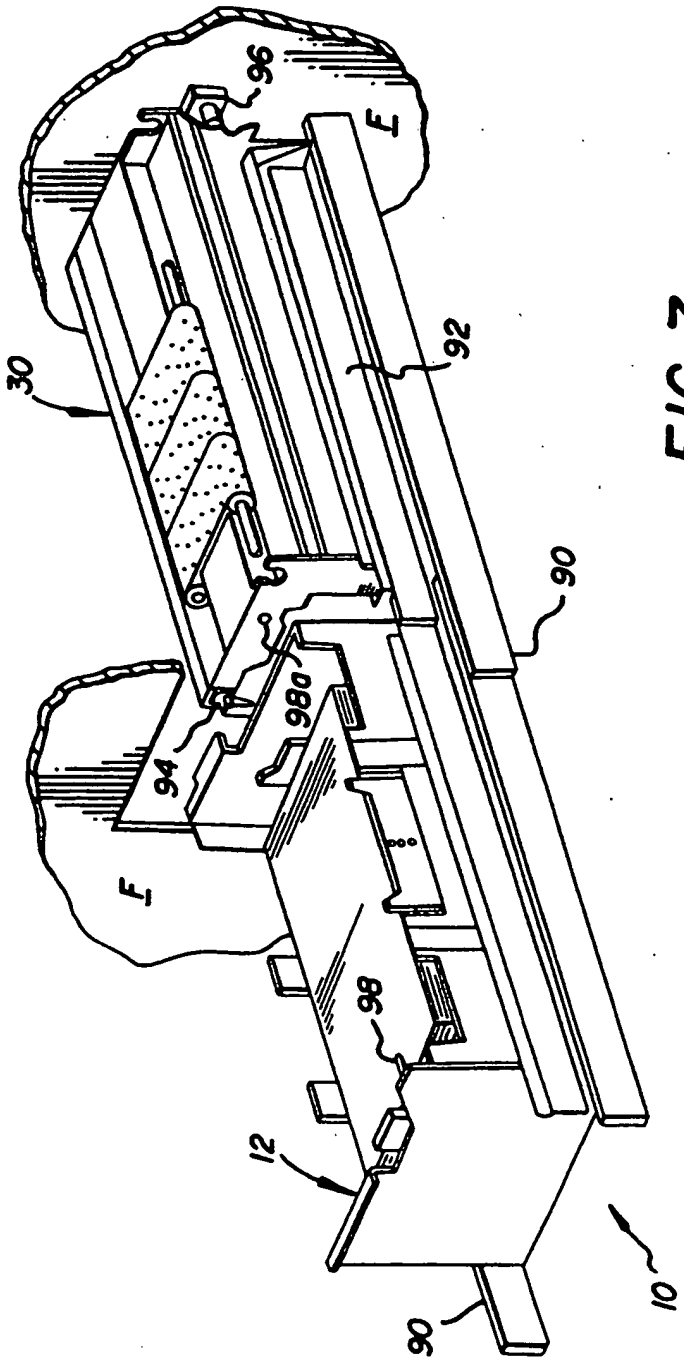

FIG. 7

VACUUM BELT FEEDER HAVING A POSITIVE AIR PRESSURE SEPARATOR AND METHOD OF USING A VACUUM BELT FEEDER

BACKGROUND OF THE INVENTION

The present invention relates in general to sheet handling apparatus for reproduction apparatus for example, and more particularly to a receiver sheet supply and feed apparatus, including a vacuum corrugation belt feeder and a positive air pressure separator.

In typical reproduction apparatus such as copiers or printers, for example, information is reproduced on individual cut sheets of receiver material such as plain bond paper or transparencies. Such receiver sheets are stored in a stack and fed seriatim when copies are to be reproduced. The sheet feeder for the reproduction apparatus must be able to handle a wide range of sheet types and sizes reliably and without damage. Sheets must be fed individually; that is, without misfeeds or multi-feeds.

Reproduction apparatus sheet feeders are typically of two types, vacuum feeders or friction feeders. One type of vacuum feeder is shown in U.S. Pat. No. 4, 169,676, issued Oct. 2, 1979, in the name of Russel. This vacuum feeder, commonly referred to as an oscillating vacuum feeder, includes an oscillating tube through which vacuum is applied to tack a sheet to the surface of the tube (sheet acquisition) for withdrawal from the sheet supply stack. Nip rollers, in cooperative relation with bearings on the tube downstream of sheet acquisition zone in a sheet feeding direction, urge a separated sheet from the sheet supply stack along a feed path away from the supply stack. While such feeder is considered to be highly effective, it does have some limitations in feeding extremely light or heavyweight papers. It is also noisy due to both its mechanical oscillation requirements and its need to utilize a high flow/high pressure vacuum source.

Another type of vacuum feeder is shown in U.S. Pat. No. 4,635,921, issued Jan. 13, 1987, in the name of Thomas. This vacuum feeder, commonly referred to as a vacuum corrugation feeder, includes a vacuum plenum for acquiring a sheet from a supply stack. The top sheets in the stack are levitated by fluffer (positive air pressure) jets. Ported belts entrained about the plenum are driven to transport a sheet vacuum tacked to the belts from the supply stack. This type of feeder is highly efficient but is still subject to misfeeds/multi-feeds, and has certain limitations with regard to the range of types of sheet materials that can be reliably handled.

Yet another type of vacuum feeder is shown in U.S. Pat. No. 4,184,672, issued Jan. 22, 1980, in the names of Watkins et al, and U.S. Pat. No. 4,327,906, issued May 4, 1982 in the names of Frölich et al. This type of vacuum feeder, commonly referred to as a vacuum picker or sucker, includes a plurality of cup-like structures connected to a vacuum source and movable to selectively pick up a sheet from a supply stack for transport from the stack. Such feeder requires a complicated mechanical arrangement to accomplish its desired pick up and transport function.

One type of friction feeder is shown in U.S. Pat. No. 4,374,212, issued Feb. 5, 1983, in the names of Martellock et al, and U.S. Pat. No. 4,381,860, issued May 3, 1983, in the name of Silverberg. This type of friction feeder, commonly referred to as a scuff feeder, includes a member (respectively shown as a belt or paddle wheel, but may also comprise a roller) which relies on frictional engagement with a sheet for removal of the sheet from a supply stack. Scuff feeders are of the simplest construction and are the cheapest to manufacture. However, since sheet materials exhibit a wide variation in friction characteristics, scuff feeders are the least reliable of the discussed group of feeders.

SUMMARY OF THE INVENTION

In view of the foregoing discussion, this invention is directed to an apparatus for storing a stack of sheets in a supply hopper and reliably and efficiently feeding sheets seriatim from the sheet supply stack. The apparatus comprises a sheet feed head assembly including a plenum, a vacuum source in flow communication with the plenum, and a mechanism, such as a feed belt, for example, associated with the plenum for urging a sheet acquired by vacuum in a sheet feeding direction away from the sheet supply stack. The sheet supply stack is supported so as to maintain the topmost sheet in such stack at a predetermined level in spaced relation with respect to the urging mechanism of the sheet feed head assembly. A first positive air supply directs a flow of air at the sheet supply stack to levitate the top several sheets in the supply stack to an elevation enabling the topmost sheet to be acquired by vacuum from the sheet feed head assembly plenum; and a second positive air supply directs a flow of air at an acquired sheet to assure separation of any additional sheets adhering to such topmost sheet.

The invention, and its objects and advantages, will become more apparent in the detailed description of the preferred embodiments presented below.

BRIEF DESCRIPTION OF THE DRAWINGS

In the detailed description of the preferred embodiments of the invention presented below, reference is made to the accompanying drawings, in which:

FIG. 1 is a side elevational view of the receiver sheet supply and feeding apparatus according to this invention;

FIG. 2 is a top plan view of the receiver sheet supply and feeding apparatus of FIG. 1, with portions removed or broken away to facilitate viewing;

FIG. 3 is a side elevational view of a cross-section of the receiver sheet supply and feeding apparatus taken along lines 3—3 of FIG. 2, particularly showing the platform elevating mechanism;

FIG. 4 is a side elevational view, on an enlarged scale and with portions removed, of a portion of the receiver sheet supply and feeding apparatus particularly showing the feed head assembly thereof;

FIG. 5 is an end view, on an enlarged scale and with portions removed, of a portion of the receiver sheet supply and feeding apparatus, particularly showing the feed head assembly thereof, taken along the lines 5—5 of FIG. 3;

FIG. 6 is an end view, on an enlarged scale and with portions removed, of a portion of the receiver sheet supply and feeding apparatus, particularly showing the air supply jets, taken along the lines 6—6 of FIG. 3;

FIG. 7 is a view, in perspective, of the sheet supply and feed apparatus, according to this invention, in association with a typical reproduction apparatus, the hopper of the sheet supply and feed apparatus being in its remote location, portions being removed or broken away to facilitate viewing; and

FIG. 8 is a side elevational view, partly in cross-section, of a side/rear guide of the sheet supply and feeding apparatus according to this invention.

DETAILED DESCRIPTION OF THE INVENTION

Referring now to the accompanying drawings, FIGS. 1 and 2 generally best show the receiver sheet supply and feeding apparatus according to this invention. The receiver sheet supply and feeding apparatus, designated generally by the numeral 10, includes an open hopper 12 and an elevating platform 14 for supporting a stack of sheets. A sheet stack (designated by the letter S) supported on the platform 14 contains individual sheets suitable, for example, for serving as receiver sheets for having reproductions formed thereon in a copier or printer device. Sheets for receiving reproductions may be selected from a wide variety of materials and sizes. For example, the sheets may be of a weight in the range of 13 pound bond to 140 pound index, and a size in the range of 8×5 inches to 11×17 inches.

The sheet stack supporting platform 14 is supported within the hopper 12 for substantially vertical elevational movement by lifting mechanism L. The lifting mechanism L serves to raise the platform 14 to an elevation for maintaining the topmost sheet in the stack S at a predetermined level during operation of the receiver sheet supply and feeding apparatus 10, and lower the platform to permit adding sheets thereto. The lifting mechanism L includes a motor M_1, attached to the outside of the upstanding front wall of the hopper 12 (see FIG. 1). The motor M_1 rotates an output gear 16 in mesh with a gear 18*a* mounted on a shaft 18 extending from the upstanding front wall of the hopper 12 through the upstanding rear wall of the hopper (see FIG. 2). A pair of pulley mounted lifting chains 20 are respectively interconnected by gears 18*b* with the shaft 18 to be moved about a closed loop path when the shaft 18 is rotated by the motor M_1.

Each of the lifting chains have a link 22 extending through a slot 12*a* respectively in the front and rear upstanding wall of the hopper 12. The links 22 are connected to respective pulleys 24 mounted on a shaft 24*a* supported in brackets 24*b* extending from the underside of the platform 14 (see FIG. 3). Tension cables 26 are respectively connected, at the ends 26*a*, 26*b* thereof, to the front and rear upstanding wall of the hopper 12. The cables are respectively threaded over their associated pulleys 24 and under pulleys 28 mounted on a shaft 28*a* supported in brackets 28*b* extending from the underside of the platform 14.

In FIG. 1, the sheet stack supporting platform 14 is shown in its most elevated position in solid lines, and in its lowest position in phantom. During the operation of the lifting mechanism L, an appropriate signal to the motor M_1 causes the motor to rotate the gear 16, either clockwise (in FIG. 1) to lower the platform 14 toward the lowest position or counterclockwise to raise the platform toward its most elevated position. Rotation of the gear 16 moves the lifting chains 20 in their closed loop paths imparting vertical movement to the links 22. This movement, in turn, moves the shaft 24*a*, and thus the platform 14 and its brackets 24*b* and pulleys 24. The platform 14 is maintained substantially level in its movement by the action of the tension cables 26 which cooperatively move the pulleys 28 and thus the shaft 28*a* and brackets 28*b* of the platform. Maintaining the topmost sheet at the predetermined level is accomplished by a sheet detecting switch 80 (see FIG. 5) which controls the operation of the motor M_1 for actuating the lifting mechanism L, in the manner to be explained hereinbelow, to raise the platform 14 through a predetermined increment. On the other hand, lowering of the platform 14 is usually accomplished by some externally produced signal to the motor which tells the motor to rotate for a time sufficient to bring the platform to its lowest position.

Of course, other precisely controllable lifting mechanisms, such as worm gears or scissor linkages, are suitable for use in elevation control for the sheet stack supporting platform according to this invention.

A sheet feed head assembly, generally designated by the numeral 30, is located in association with the hopper 12 so as to extend over a portion of the platform 14 in spaced relation to a sheet stack supported thereon. The sheet feed head assembly 30 includes a ported plenum 32 connected to a vacuum source V, and an air jet device 40 connected to a positive pressure air source P. As will be more fully explained hereinbelow, according to this invention a positive pressure air jet from the device 40 levitates the top several sheets in the supported sheet stack S, vacuum at the plenum 32 is effective through its ports 32*p* (see FIG. 4) to cause the topmost levitated sheet from the stack to thereafter be acquired at the plenum for separation from the sheet stack, and additional positive pressure air jets from the device 40 assure separation of subsequent sheets from the acquired topmost sheet.

The lower surface 32*a* of the plenum 32 of the sheet feed head assembly 30 has a particularly configured shape (shown in FIG. 5) so as to provide for a specific corrugation of an acquired sheet. As the top sheets in the supported sheet stack are levitated, the topmost sheet contacts the outer winged portions 32*b* of the surface 32*a*. A minimal pressure is exerted on the cross-track marginal edges of the sheet to help in forming a controlled corrugation to the sheet. This establishes a consistent spacing for the center portion of the sheet from the center portion of the plenum 32. As such, the access time for a sheet to be acquired at the plenum is repeatably consistent and readily predictable. The interactions of the plenum 32, the air jet device 40, and a front stop (designated by the numeral 60 and more fully described hereinbelow) assure that control over the sheet as it is acquired at the plenum is never lost. Further, corrugation of the sheet contorts the sheet in an unnatural manner. Since subsequent sheets are not subjected to the same forces, at the same time, as is the topmost sheet, such subsequent sheets are unable to contort in the same manner. Accordingly, the subsequent sheets are effectively separated from the topmost sheet as it is being acquired at the plenum.

In a preferred embodiment for efficiently handling typical receiver sheets, for use in an exemplary reproduction apparatus, of a weight and a size described above, the vacuum source V may create a flow rate in the range of approximately 35 cu. ft./min. to 60 cu. ft./min., with 47–53 cu. ft./min. being optimum. A valve 38 (see FIG. 5), of the bleed-off, poppet or gravity door type for example, is used to limit the vacuum level once a sheet has been acquired at the plenum 32. Limiting of the vacuum level aides in limiting air bleed through of some porous type sheet materials. Vacuum bleed through for a porous sheet may potentially cause the undesirable condition where a subsequent sheet will adhere to the acquired sheet and result in a multi-feed.

Additionally, limiting the vacuum level reduces the amount of energy required to transport the acquired sheet forward in the sheet feed direction. That is, the vacuum induced normal forces holding the sheet to the plenum 32 are reduced so that the sheet may be more readily transported, in the manner described hereinbelow, in the feed direction with substantially less drag.

A switch 36, for example a pressure or mechanically activated switch, is attached to the plenum to detect when a sheet has been acquired. A signal provided by the switch on detection of sheet acquisition is utilized to control operation of various components of the sheet feed head assembly 30, such as timing of activations or setting of air flow levels, to optimize operation for a particular type (size) of sheet to be fed from the sheet supply and feeding 10 according to this invention.

The sheet feed head assembly 30 additionally includes a belt mechanism 34 for transporting an acquired sheet in a feed direction (designated by the arrow A in FIGS. 2 and 3) away from the sheet stack S toward a downstream location. The belt transport mechanism 34 has a plurality of belts 36 entrained about rollers 38 to establish a closed loop path about the plenum 32. The lower runs of the belts 36 are in intimate contact with the lower surface 22*a* of the plenum 22 (see FIG. 5). The acquired sheet from the sheet stack S is effectively tacked to the belts by air pressure resulting from the application of vacuum in the plenum 32 through the plenum ports 32*p* and the belt ports 36*p*.

The belts 36 are selectively driven in a direction (counter-clockwise in FIGS. 3 and 4) to remove the acquired sheet from the area above the sheet stack S and transport the sheet in the feed direction A along a travel path to a downstream transport, such as driven feed nip roller pair 50. The nip roller pair 50 is driven by a motor M_2. A gear 52 is rotatably mounted on a shaft 54 supporting one roller of the nip roller pair. A clutch 56 is selectively activated to couple the gear 52 to the shaft 54 for rotation with the shaft. An intermediate gear 58 is in mesh with the gear 52 and a gear (not shown) coupled to one of the belt rollers 38. Accordingly, when the clutch 56 is activated, the belts 36 will be driven so as to feed an acquired sheet such that the acquired sheet is transported from the sheet stack S and is thereafter available for any further processing, such as receiving a reproduction from a copier or printer, for example.

The hopper 12 incorporates a front stop 60, a rear stop 62 and side stops 64 arranged to engage the marginal edges of a sheet stack S supported on the platform 14 and accurately locate the sheet stack relative to the sheet feed head assembly 30. The front stop 60 additionally provides a lead edge guide for the topmost sheet in the sheet stack as it is removed from the stack for acquisition, and also serves as a retard mechanism for any sheets adhering to the topmost sheet as it is removed. The positive pressure air jet device 40 of the sheet feed head assembly 30 is located adjacent to the front stop 60 on the opposite side thereof from the sheet supporting platform 14. As noted above, the air jet device 40 is for the purpose of levitating the top sheets in the sheet stack S and separating subsequent sheets adhering to the topmost sheet when acquired for removal from the sheet stack.

The positive pressure air jet device 40 includes a first air jet arrangement 42 and a second air jet arrangement 44. The first air jet arrangement 42 incorporates a single nozzle 42*a* in flow communication with a source of positive pressure air P. The nozzle 42*a* is located substantially along the center line C (see FIG. 2) of the sheet stack S, in the cross-track direction, and is aimed at the location where the top of the sheet stack will be positioned by the sheet support platform 14. The single nozzle 42*a* directs a high pressure air stream at the sheet stack, in the center of the lead edge, to fluff the top several sheets in the stack to bring the topmost sheet into association with the sheet feed head assembly 30 where it can be acquired, by vacuum, at the plenum 32.

The cross-sectional area of the nozzle 42*a* of the first air jet arrangement 42 is shaped as a tear drop (see FIG. 6). The top portion of the tear drop is approximately ½ the dimension of the bottom portion so as to apply a larger amount of air at the bottom of the nozzle than at the top. In the preferred embodiment, the nozzle 42*a* is between 0.300 inch to .600 inch (in the vertical dimension), between, 0.075 inch to 0.250 inch across the bottom portion of the tear drop, and between 0.0375 inch to 0.125 inch across the top portion of the tear drop. The location of the nozzle 42*a* to the sheet stack supported on the platform 14 is to have the nozzle 0.125 (±0.060) inch away from the lead edge of the sheet stack and the topmost sheet in the stack approximately 0.125 (±0.060) inch below the top point of the tear drop. The nozzle, which has a substantially vertical face 42*a'*, has an air channel that is oriented approximately 25° to 35° from the vertical.

With the nozzle 42*a* configured in the above described manner, the top several sheets in the sheet stack S begin separation between each sheet and the topmost sheet rises, along its center line C in the feed direction A, to a controlled height above the sheet stack. The positive air flow through the nozzle can be pulsed from a low to a high flow rate, or may be left on at a high flow rate. Again, referring to the preferred embodiment, the air flow is in the range of between 1.5 cu. ft./min. to 4.5 cu. ft./min., with 1.75 cu. ft./min. being optimum. It has been found that air volume, velocity, and sheet weight can all vary within the described limits and still provide a consistent and controlled height to the levitated topmost sheet. Once the sheets have started to levitate (fluff up) in the center, the topmost sheet will rise to the outside corrugation points of the plenum 32. The air flow going into the stack will ideally be allowed to proceed through the stack out the rear thereof, with some finding its way out through the sides of the stack.

Of course, employing the described parameters for the first air jet arrangement 42, modifications to such air jet arrangement may be envisioned as suitable for use in the sheet feed supply and feeding apparatus 10 according to this invention. For example, two converging positive pressure air jets may be employed. Further, the nozzle may have a round or oval cross-section (although this may result in a somewhat degraded performance over the performance with the preferred tear drop shaped cross-section). Additionally, the nozzle may be integrally formed with the front stop 60.

The second air jet arrangement 44 incorporates a plurality of nozzles 44*a* (preferably six in number) in common flow communication with the source of positive pressure air P (or, alternatively, a second separate source of pressurized air). The nozzles 44*a* are aimed at the location where the top of the sheet stack will be positioned by the sheet support platform 14, and slightly downstream of the aim point for the first air jet nozzle 42*a* (see FIG. 1). The purpose of the second air jet arrangement 44 is to separate any sheets adhering to the

topmost sheet acquired by the sheet feed head assembly 30 for removal and transport from the sheet stack S.

As discussed above, it has been found that subsequent sheets adhering to the acquired topmost sheet are not able to form the corrugations caused by the different ribs and bends of the lower surface 32*a* of the plenum 32 (as does the topmost sheet when properly acquired). Thus, pockets are formed between the topmost sheet and any subsequent adhering sheets. The air stream provided by the second air jet arrangement 44, by its location and aim, is directed into the pockets and forces the subsequent sheets back down to the sheet stack S. As such, subsequent sheets are in effect retarded and thus substantially prevented from being fed with the acquired topmost sheet, as a multi-feed condition.

In the preferred embodiment, the nozzles 44*a* of the second air jet arrangement 44 are angled approximately 25° to 35° from the horizontal face of the subsequent sheets. The nozzles 44*a* have a cross-sectional area in the shape of a semicircle (see FIG. 6). This enables the bottom of the air streams from the respective nozzles focused such that it is aimed within approximately 0.125 inch from the lead edge of the topmost sheet acquired by the plenum 32. The cross-sectional area of the nozzles is respectively between 0.0122 sq. in. and 0.0382 sq. in. The air flow for each of the plurality of nozzles 44*a* is, as in the case of the air flow for the nozzle 42*a* of the first air jet arrangement 42, in the range of between 1.5 cu. ft./min. to 4.5 cu. ft./min., with 1.75 cu. ft./min. being optimum. Accordingly, the total air flow is in the range of between 9–27 cu. ft./min., with 10.5 cu. ft./min. being optimum. The air flow may be pulsed from an off or medium flow rate to a high flow rate.

Turning now to a more detailed description of the front stop 60, the front stop comprises a plate 70 having a surface 70*a* against which the lead edge of the stack of sheets S is positioned to accurately locate the stack, in the sheet feed direction, relative to the sheet feed head assembly 20. The plate 70 has a pair of upstanding fingers 72. The fingers 72 serve to maintain the in-track position of the sheets of the stack as the sheets are levitated by the first air jet arrangement 42. That is, the topmost sheet and a number of subsequent sheets levitate, but are kept from moving forward relative to the sheet stack S by the fingers 72. The tops 72*a* of the fingers are configured to have an angle substantially equal to the corrugation of the plenum surface 32*a* respectively adjacent thereto. This establishes a restricted sheet passage (see FIG. 5) through which only a properly corrugated sheet can pass. Any subsequent sheets adhering to the topmost acquired sheet will not have the proper corrugation, as explained above, and will be blocked by the fingers 72 so that they will not be able to be transported away from the sheet stack. If not for the fingers, the subsequent sheets could be dragged forward during transport of the topmost sheet by the belts 36 creating a multi-feed condition or incorrectly locating the subsequent sheets for the beginning of the next feed cycle. The spacing of the fingers 72 is selected to enable substantially free positive air flow from the first and second air jet arrangements 42, 44 therebetween.

As noted above, the hopper 12 also incorporates a rear stop 62. The rear stop 62 is necessary to prevent sheets levitated from the sheet stack S by the first air jet arrangement 42 from moving toward the rear (relative to the sheet stack) by the positive air pressure exerted on the sheets. The rear stop 62 is adjustably mounted (on guide rods for example) for selective positioning in the sheet feed direction A so as to positively engage the rear edge of a sheet stack, of any of a variety of dimensions in the sheet feed direction, supported on the platform 14 and engaged at its lead edge with the front stop 60. As best shown in FIG. 8, the rear stop 62 is also supported on an index rod 74. The rear stop is manually movable along the guide and index rods to a selected position corresponding to a dimension of the sheet stack in the in-track direction (measured from the front stop 60). The rear stop 62 is locked in the selected position by a member 62*a* interconnected to the rear stop by a tension spring 76. The spring 76 urges the lead edge of the member 62*a* into positive locking engagement with a selected one of a plurality of grooves 74*a* spaced along the index rod 74. Adjustment of the rear stop 62 is thus accomplished by manually moving the member 62*a* against the urging of the spring 76 out of association with the grooves and then sliding the stop along the index rod 74. When the rear stop 62 is correctly positioned along the rods, the member 62*a* is then released and will engage a corresponding groove of the index rod 74 to lock the rear stop in the desired position.

The rear stop 62 also includes a loading device 78, such as a leaf spring. The purpose of the loading device 78 is to exert a pressure on the top portion of the sheet stack S (and the levitated sheets) to assure that the sheets are maintained against the front stop 60. As such, the levitated sheets are maintained in their position relative to the sheet stack against the fingers 72 of the front stop 60. However, it is an important aspect of this invention that the positive air flow from the air jet device 40 between the levitated sheets be allowed to escape from the rear of the sheets. If the air flow were to be restricted, the corrugation of the topmost sheet will become unpredictable and thus the efficiency in acquiring the sheet by the sheet feed s head assembly 30 will be substantially reduced. Accordingly, the rear stop 62 is formed as two substantially identical assemblies spaced apart on opposite sides of the supported sheet stack center line C. Of course, a single assembly with a large opening spanning the area through which the air flow can pass substantially unrestricted is also suitable for use with this invention.

A sensor SN is utilized to detect the position of the rear stop 62. From the detected position, it is possible to determine the in-track dimension of the sheets in the sheet stack S and optimize timing of functions related to the feeding of sheets seriatim from the stack. It should be noted that the side stops 64 are of generally the same construction as that of the rear stop 62 (the exception being that only one of the side stops includes a loading device). Similar sensors are used to detect the positions of the side stops for determining, for example, the cross-track dimension of the sheet stack supported on the platform 14.

As noted above, it is important to the proper operation of the sheet supply and feeding apparatus 10 according to this invention for the level of the topmost sheet in the stack supported on the platform 14 to be maintained at a predetermined height relative to the plenum 32. The level is selected to be in a range where the topmost sheet, when levitated by the first air jet arrangement 42, is close enough to the plenum 32 to be readily acquired by the vacuum forces from the plenum within a repeatable time frame, and far enough away from the plenum to assure that the sheet being acquired is not pinned by the plenum. Pinning of the sheet would result in misfeeds or skew.

The switch 80, as noted above, is for the purpose of detecting the level of the topmost sheet. Such switch (see FIG. 5) is, for example, a pin that rides against the sheet, with very little downward pressure, at the highest level of acceptable corrugation. The pin is integrated into a hall effect switch so as to cause limited pressure on the sheet. The switch 80 is made during the feed cycle of the sheet feed head assembly 30 and read during the feed interval to effect raising of the platform 14 to maintain the proper sheet level. The location of the switch 80 at the highest level of acceptable corrugation is an advantage in that the switch will sense the location of sheets which may be severely curled and still not pin the sheet to the plenum. The switch 80 may also be used to determine the weight (thickness) of the receiver sheets being fed from any particular stack on the platform 14. Signals from the switch 80 can be interpreted to determine the number of sheets fed from the sheet stack per incremental elevation of the platform 14. Such number is directly relatable to the weight of the sheet material. The weight of the sheet material is a useful parameter to know when setting air (pressure or vacuum) levels for optimum operation of the sheet supply and feeding apparatus 10.

Another important aspect of the supply and feeding apparatus 10 according to this invention is that the hopper 12 and the sheet feed head assembly 30 are cooperatively associated so as to be selectively movable either together or independently. The purpose of such association is to enable the hopper 12 to be readily accessed for placement of a stack of sheets therein, and to enable the entire supply and feeding apparatus 10 to be readily accessible for maintenance or jam clearance. As particularly discussed above, the supply and feeding apparatus 10 is typically associated with a reproduction apparatus for providing sheets thereto for enabling copies to be made on such sheets. The supply and feeding apparatus 10 is normally precisely located at an operative position within the frame of the reproduction apparatus in a predetermined alignment to assure feeding of sheets along an established feed path. However, under certain circumstances, such as loading the hopper 12 or clearing jams, the various components of the apparatus 10 must be readily accessible by an operator. Generally, this requires that the apparatus 10 be movable to a position remote from the operative position (e.g., external to the reproduction apparatus).

Accordingly, as shown in FIG. 7, the supply and feeding apparatus 10 is mounted on slide rails 90 which are supported within the frame F of an exemplary reproduction apparatus. In turn, the sheet feed head assembly 30 is mounted in a slide rail 92, and on roller assembly 94, supported by the hopper 12. A passive latch 96, such as a magnet or spring detent assembly, for example, releasably couples the sheet feed head assembly 20 to the frame F of the reproduction apparatus. The strength of the passive latch 96 is set to assure that it will normally overcome the forces of the hopper 12 moving in the slide rails 90 to hold the assembly 30 at the operative position. In this manner, when the hopper 12 is moved in the slide rails 90 to its remote position for loading of a sheet stack therein, the sheet feed head assembly 30 is retained within the apparatus, with the roller assembly serving to help in the support of the sheet feed head assembly. Thus, the interior of the hopper 12 is readily accessible for loading of the sheet stack on the platform 14. However, for jam clearance or general maintenance, the sheet feed head assembly 30 can be manually urged to overcome the passive latch such that the assembly moves on the slide rail 92 and roller assembly 94 to the remote location with the hopper 12 for ready access. It is pointed out that the hopper 12 has a tapered pin 98 extending from the upstanding wall away from the front of the reproduction apparatus. The pin 98 is aligned with a hole 98*a* defined in the sheet feed head assembly 30. Receipt of the pin 98 in the hole 98*a* assures the accurate alignment of the sheet feed head assembly with the hopper to establish a unitary arrangement. On return to the operative position within the reproduction apparatus, the hopper 12 and the sheet feed head assembly 30 are moved substantially together.

The invention has been described in detail with particular reference to preferred embodiments thereof, but it will be understood that variations and modifications can be effected within the spirit and scope of the invention as set forth in the claims.

What is claimed is:

1. Apparatus for feeding sheets seriatim from a sheet supply stack, said apparatus comprising:

a sheet feed head assembly including a plenum, a vacuum source in flow communication with said plenum, and means associated with said plenum for urging a sheet acquired by vacuum in a sheet feeding direction away from the sheet supply stack;

means for supporting the sheet supply stack so as to maintain the topmost sheet in such stack at a predetermined level in spaced relation with respect to said urging means of said sheet feed head assembly;

first positive air supply means for directing a flow of air at the sheet supply stack to levitate the top several sheets in the supply stack to an elevation enabling the topmost sheet to be acquired by vacuum from said sheet feed head assembly plenum, said first air supply means including a source of pressurized air and a nozzle in flow communication with said pressurized air source of said first air supply means, said nozzle being located in a plane substantially coincident with the center of the supported sheet stack measured in a direction transverse to the sheet feed direction, and oriented so as to aim a stream of pressurized air at the top portion of a sheet supply stack supported on said stack supporting means; and

second positive air supply means for directing a flow of air at an acquired sheet to assure separation of any additional sheets adhering to such topmost sheet, said second air supply means including a source of pressurized air and a plurality of nozzles in flow communication with said pressurized air source of said second air supply means said nozzles being oriented so as to aim a stream of pressurized air with a component in the direction opposite to the sheet feeding direction, toward the sheet supply stack, substantially parallel to the air stream of said first air supply means and downstream of the aim of the air stream of said first air supply means.

2. The sheet feeding apparatus of claim 1 wherein said pressurized air source of said first air supply means is selected to provide a stream of pressurized air of sufficient flow to travel through the supported stack and exit at the rear of such stack in a direction opposite to the sheet feed direction.

3. The sheet feeding apparatus of claim 2 wherein said pressurized air source of said first air supply means is selected to provide a stream of pressurized air of a flow

in the range of approximately between 1.5–4.5 cu. ft./min.

4. The sheet feeding apparatus of claim 1 wherein said nozzle of said first air supply means is of a cross-sectional shape substantially approximating a tear drop.

5. The sheet feeding apparatus of claim 4 wherein the tear drop shape of said nozzle of said first air supply means is such that the dimension at the top portion of the tear drop is approximately one-half the dimension of the bottom portion of the tear drop.

6. The sheet feeding apparatus of claim 1 wherein said vacuum source is selected to provide an air flow in the range of approximately between 35–60 cu. ft./min.

7. The sheet feeding apparatus of claim 1 wherein said sheet supply stack supporting means includes a platform for supporting the supply stack of sheets, and a front stop, side stops, and an adjustable rear stop for accurately locating the sheet supply stack on said platform.

8. The sheet feeding apparatus of claim 7 wherein said front stop includes a pair of spaced upstanding fingers for guiding levitated top sheets of the sheet supply stack while permitting substantially unimpeded flow of air from said first positive air supply means therebetween.

9. The sheet feeding apparatus of claim 7 wherein said rear stop includes means for urging the top sheets in the sheet supply stack toward said front stop.

10. The sheet feeding apparatus of claim 9 wherein said urging means of said rear stop is a leaf spring.

11. The sheet feeding apparatus of claim 1 wherein said plenum of said sheet feed head assembly includes a corrugation surface facing a sheet supply stack on said stack supporting means.

12. The sheet feeding apparatus of claim 11 wherein said sheet urging means of said sheet feed head assembly includes at least one belt entrained for movement about a closed loop path, said plenum being located within such closed loop path.

13. The sheet feeding apparatus of claim 11 wherein said sheet supply stack supporting means includes a platform for supporting the supply stack of sheets and a front stop for accurately locating the sheet supply stack on said platform, said front stop including a pair of spaced upstanding fingers for guiding levitated top sheets of the sheet supply stack while permitting substantially unimpeded flow of air from said first positive air supply means therebetween, said upstanding fingers having a top surface substantially conforming to the shape of said plenum corrugation surface adjacent to thereto.

14. The sheet feeding apparatus of claim 1 wherein said plurality of nozzles respectively are of substantially semicircular cross-section.

15. The sheet feeding apparatus of claim 1 wherein said pressurized air source of said second air supply means is selected to provide a stream of pressurized air in the range of approximately between 1.5–4.5 cu. ft./min. for each of said plurality of nozzles.

16. The sheet feeding apparatus of claim 1 wherein said sheet feed head assembly and said sheet stack supporting means include means for coupling sheet feed head assembly and said sheet stack supporting means together to enable them to be selectively moved together transverse to the sheet feed direction to a remote location, or moved such that only said stack supporting means moved transverse to the sheet feed direction to a remote location.

17. The sheet feeding apparatus of claim 16 wherein said coupling means further includes a passive latch for normally retaining said sheet feed head assembly against movement with said sheet stack supporting means and enabling said sheet feed head assembly to move with said sheet stack supporting means on exertion of sufficient force on said sheet feed head to overcome said passive latch.

18. In a reproduction apparatus for making copies of original information respectively on individual sheets of receiver material, apparatus for feeding such sheets seriatim from a sheet supply stack along a feed path, said sheet supply and feeding apparatus comprising:

a platform for supporting a supply stack of individual sheets of receiver material;

means for locating said platform within said reproduction apparatus in operative relation thereto or remote from said reproduction apparatus to enable a sheet supply stack to be readily loaded on said platform;

a sheet feed head assembly locatable within said reproduction apparatus in operative relation thereto or remote from said reproduction apparatus, said sheet feed head assembly including a plenum, a vacuum source in flow communication with said plenum, and means associated with said plenum for urging a sheet acquired by vacuum in a sheet feeding direction away from the sheet supply stack;

means for selectively elevating said platform, supporting the sheet supply stack, so as to maintain the topmost sheet in such stack at a predetermined level in spaced relation with respect to said urging means of said sheet feed head assembly;

first positive air supply means for directing a flow of air at the sheet supply stack to levitate the top several sheets in the supply stack to an elevation enabling the topmost sheet to be acquired by vacuum from said sheet feed head assembly plenum, wherein said first air supply means includes a source of pressurized air and a nozzle in flow communication with said pressurized air source of said first air supply means said nozzle being located in a plane substantially coincident with the center of the supported sheet stack in a direction transverse to the sheet feed direction, and oriented so as to aim a stream of pressurized air at the top portion of a sheet supply stack supported on said stack supporting means; and

second positive air supply means for directing a flow of air at an acquired sheet to assure separation of any additional sheets adhering to such topmost sheet, wherein said second air supply means includes a source of pressurized air and a plurality of nozzles in flow communication with said pressurized air source of said second air supply means said nozzles are oriented so as to aim a stream of pressurized air with a component in the direction opposite to the sheet feeding direction, toward the sheet supply stack, substantially parallel to the air stream of said first air supply means and downstream of the aim of the air stream of said first air supply means.

19. The sheet feeding apparatus of claim 18 wherein said vacuum source is selected to provide an air flow in the range of approximately between 35–60 cu. ft./min.

20. The sheet feeding apparatus of claim 18 wherein said pressurized air source of said first air supply means is selected to provide a stream of pressurized air of a flow in the range of approximately between 1.5–4.5 cu. ft./min. sufficient to travel through the supported stack

and exit at the rear of such stack in a direction opposite to the sheet feed direction.

21. The sheet feeding apparatus of claim 18 wherein said nozzle of said first air supply means is of a cross-sectional shape substantially approximating a tear drop, the dimension at the top portion of the tear drop being approximately one-half the dimension of the bottom portion of the tear drop.

22. The sheet feeding apparatus of claim 18 wherein said sheet supply stack supporting means includes a platform for supporting the supply stack of sheets, and a front stop, side stops, and an adjustable rear stop for accurately locating the sheet supply stack on said platform, and said front stop including a pair of spaced upstanding fingers for guiding levitated top sheets of the sheet supply stack while permitting substantially unimpeded flow of air from said first positive air supply means therebetween, said rear stop including means for urging the top sheets in the sheet supply stack toward said front stop.

23. The sheet feeding apparatus of claim 22 wherein said urging means of said rear stop is a leaf spring.

24. The sheet feeding apparatus of claim 18 wherein said plenum of said sheet feed head assembly includes a corrugation surface facing a sheet supply stack on said stack supporting means, and wherein said sheet urging means of said sheet feed head assembly includes at least one belt entrained for movement about a closed loop path, said plenum being located within such closed loop path.

25. The sheet feeding apparatus of claim 18 wherein said plurality of nozzles are respectively of substantially semicircular cross-section and direct a stream of pressurized air of a flow for each nozzle in the range of approximately between 1.5–4.5 cu. ft./min.

26. The sheet feeding apparatus of claim 18 wherein said sheet feed head assembly and said sheet stack supporting platform include means for coupling sheet feed head assembly and said sheet stack supporting platform together to enable them to be selectively moved together transverse to the sheet feed direction to a remote location, or moved such that only said stack supporting platform moved transverse to the sheet feed direction to a remote location.

27. The sheet feeding apparatus of claim 26 wherein said coupling means further includes a passive latch for normally retaining said sheet feed head assembly against movement with said sheet stack supporting platform and enabling said sheet feed head assembly to move with said sheet stack supporting platform on exertion of sufficient force on said sheet feed head to overcome said passive latch.

28. A method for feeding sheets seriatim from a sheet supply stack, said method comprising the steps of:

supporting the sheet supply stack so as to maintain the topmost sheet in such stack at a predetermined level;

directing a first flow of positive pressure air at the sheet supply stack in a plane substantially coincident with the center of the supported sheet stack in a direction transverse to the sheet feed direction to levitate the top several sheets in the supply stack to an elevation above said predetermined level, wherein the flow rate for the positive pressure air to levitate the top several sheets in the supply stack is selected to be in the range of approximately between 1.5–4.5 cu. ft./min.;

acquiring the topmost sheet from the stack by vacuum, wherein the flow rate for the vacuum for acquiring the topmost sheet from the stack is selected to be in the range of approximately between 35–60 cu. ft./min.;

directing a second flow of pressurized air at an acquired sheet with a component in the direction opposite to the sheet feeding direction, toward the sheet supply stack, substantially parallel to the first flow of positive pressure air, and downstream of the aim of the first flow of positive pressure air to assure separation of any additional sheets adhering to such topmost sheet, wherein the flow rate for the positive pressure air to assure separation of any additional sheets adhering to such topmost sheet is selected to be in the range of approximately between 9–27 cu. ft./min.; and

urging a sheet acquired by vacuum in a sheet feeding direction away from the sheet supply stack.

* * * * *

US006120016A

United States Patent [19]

Watkiss

[11] Patent Number: 6,120,016

[45] Date of Patent: *Sep. 19, 2000

[54] **APPARATUS FOR FEEDING SHEET MATERIAL**

[75] Inventor: **Christopher Robin Watkiss**, Biggleswade, United Kingdom

[73] Assignee: **Watkiss Automation Limited**, Bedfordshire, United Kingdom

[*] Notice: This patent issued on a continued prosecution application filed under 37 CFR 1.53(d), and is subject to the twenty year patent term provisions of 35 U.S.C. 154(a)(2).

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[22] PCT Filed: **Mar. 18, 1996**

[86] PCT No.: **PCT/GB96/00631**

§ 371 Date: **Oct. 15, 1996**

§ 102(e) Date: **Oct. 15, 1996**

[87] PCT Pub. No.: **WO96/29270**

PCT Pub. Date: **Sep. 26, 1996**

[30] **Foreign Application Priority Data**

Mar. 18, 1995 [GB] United Kingdom 9505502

[51] **Int. Cl.**[7] **B65H 3/32**

[52] **U.S. Cl.** **271/19**; 271/20; 271/106; 271/161

[58] **Field of Search** 271/10.1, 94, 98, 271/99, 105, 106, 197, 19, 20, 16, 161, 34

[56] **References Cited**

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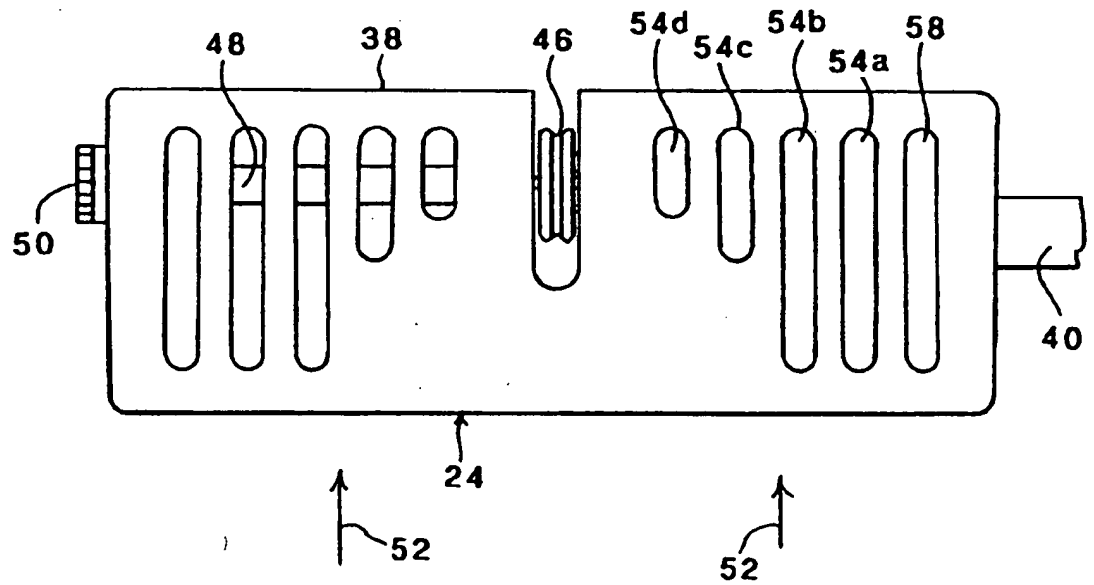
Primary Examiner—Christopher P. Ellis
Assistant Examiner—Patrick Mackey
Attorney, Agent, or Firm—Seidel, Gonda, Lavorgna & Monaco, PC

[57] **ABSTRACT**

A suction device for feeding sheets of material comprises a housing (38) connectable by a pipe (40) to a vacuum device and having apertures (54*a*, 54*b*, 54*c*, 54*d*, 58) through which a suction effect can be created. An eccentric roller (46) imparts a corrugation to the attracted sheet. The apertures are shaped and located so that there is a boost in the suction exerted on the sheet at the time that it is distorted. Continuous and pulsed air flows are used as well as aids to separate sheets individually from a stack.

17 Claims, 5 Drawing Sheets



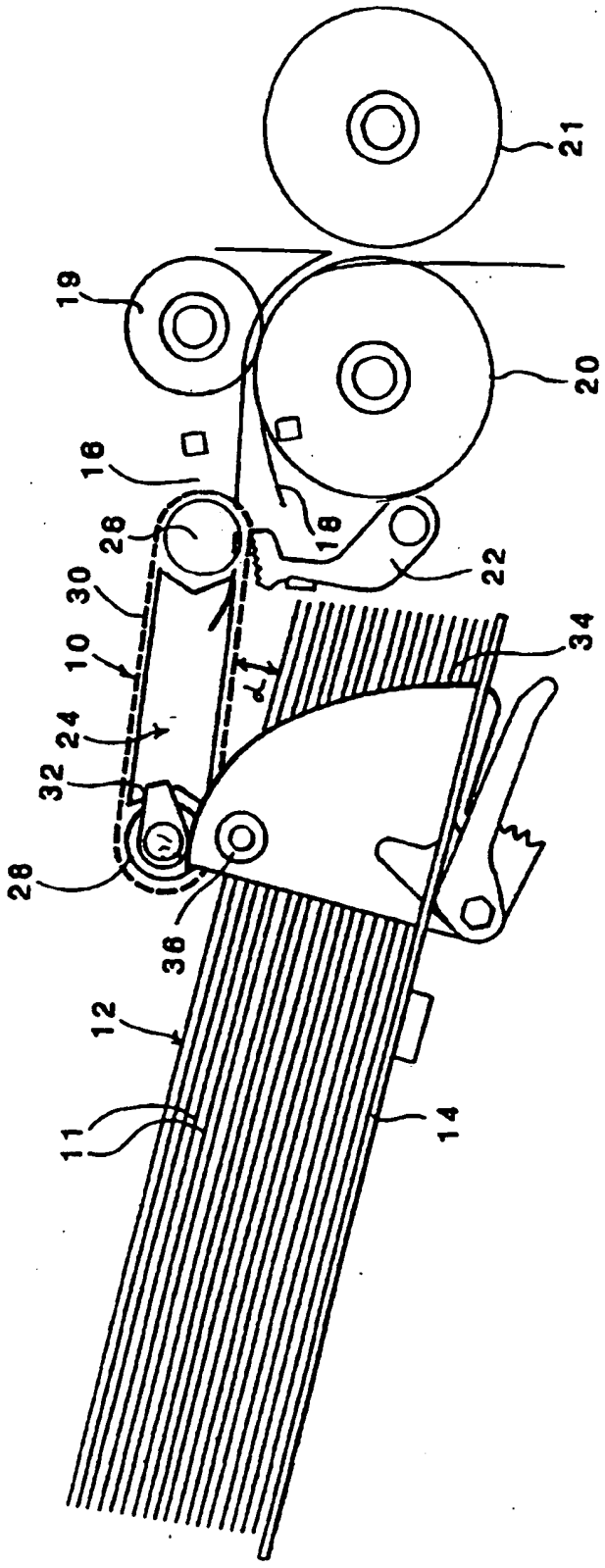


FIG.1.

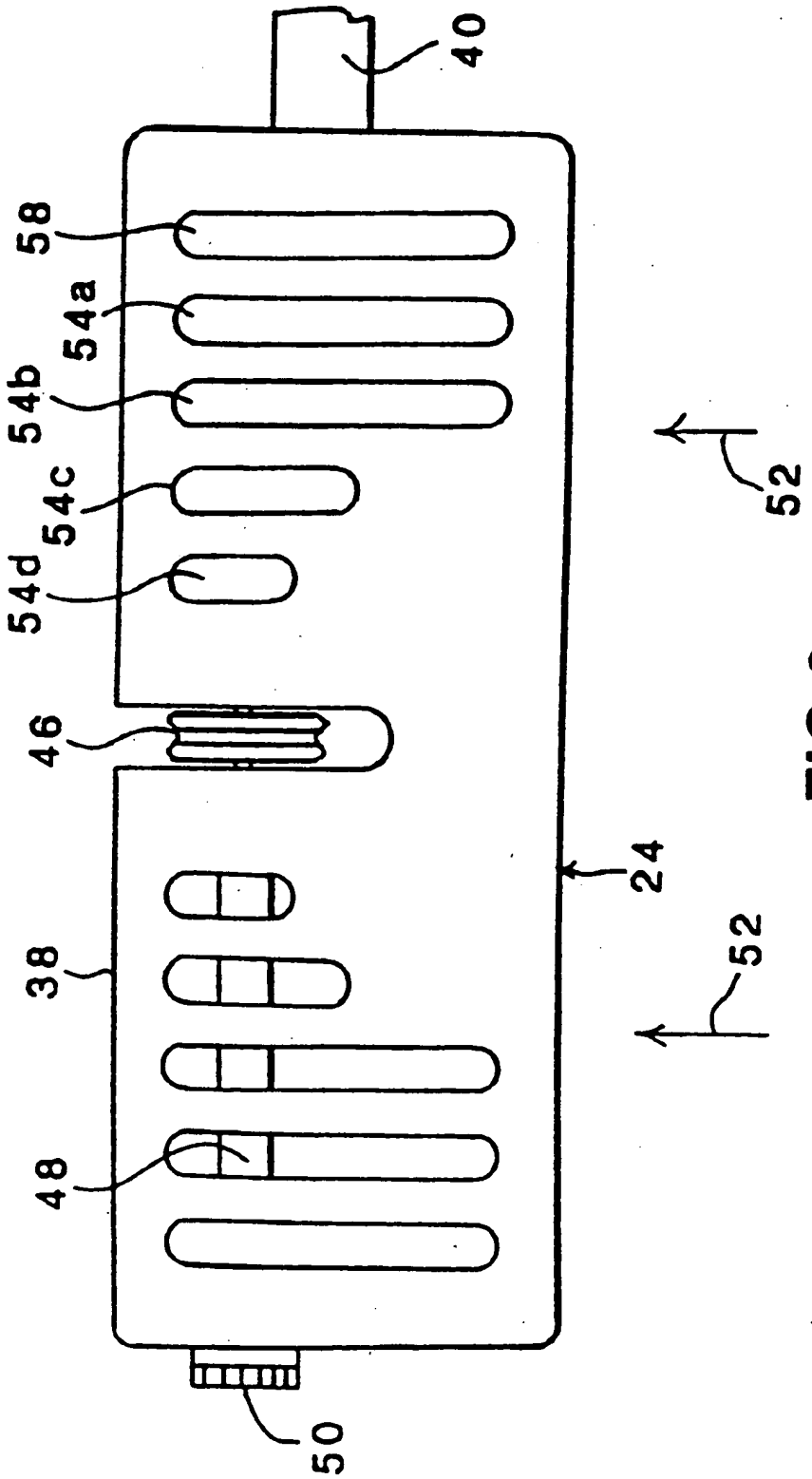


FIG.2.

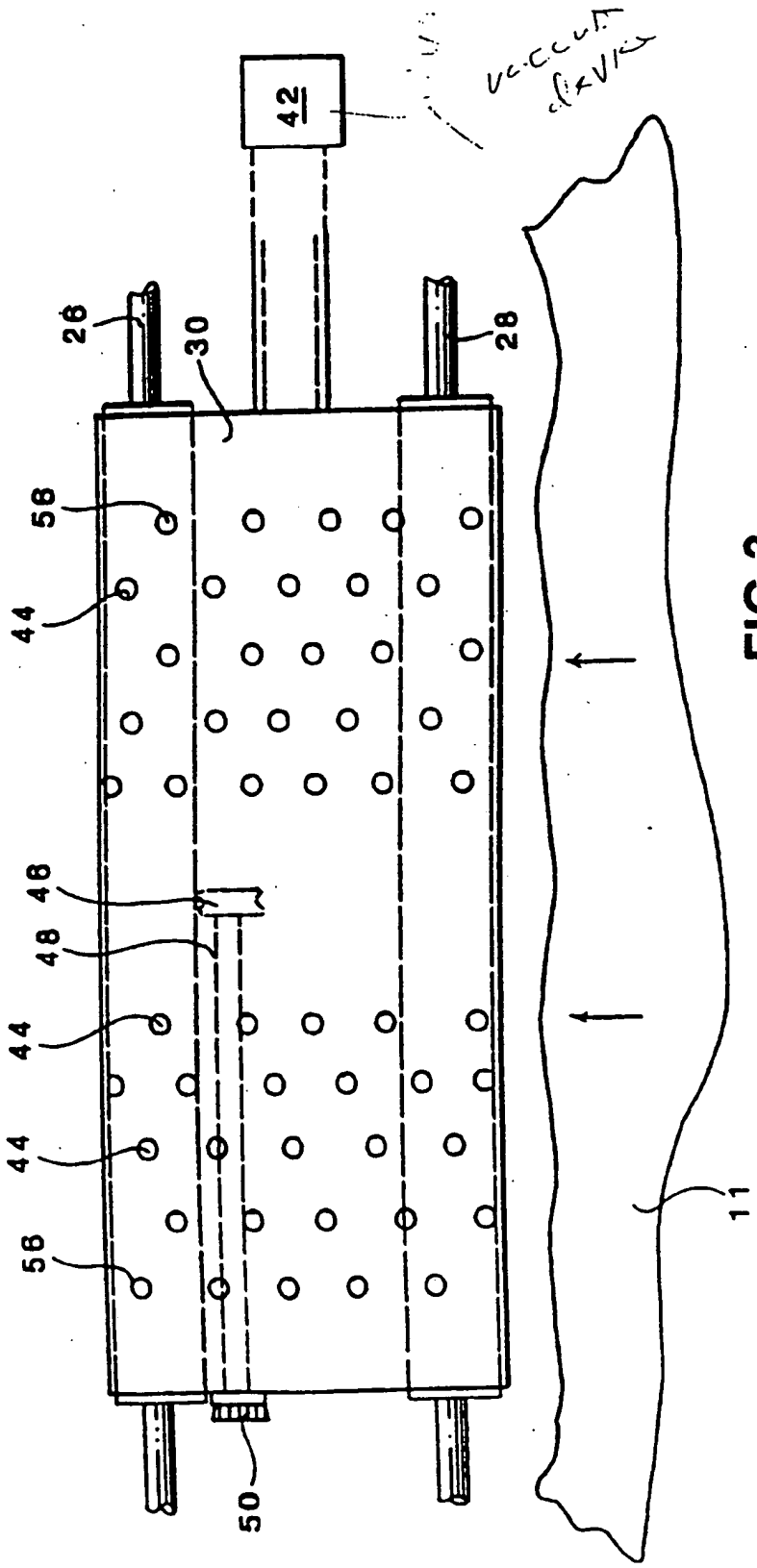


FIG.3.

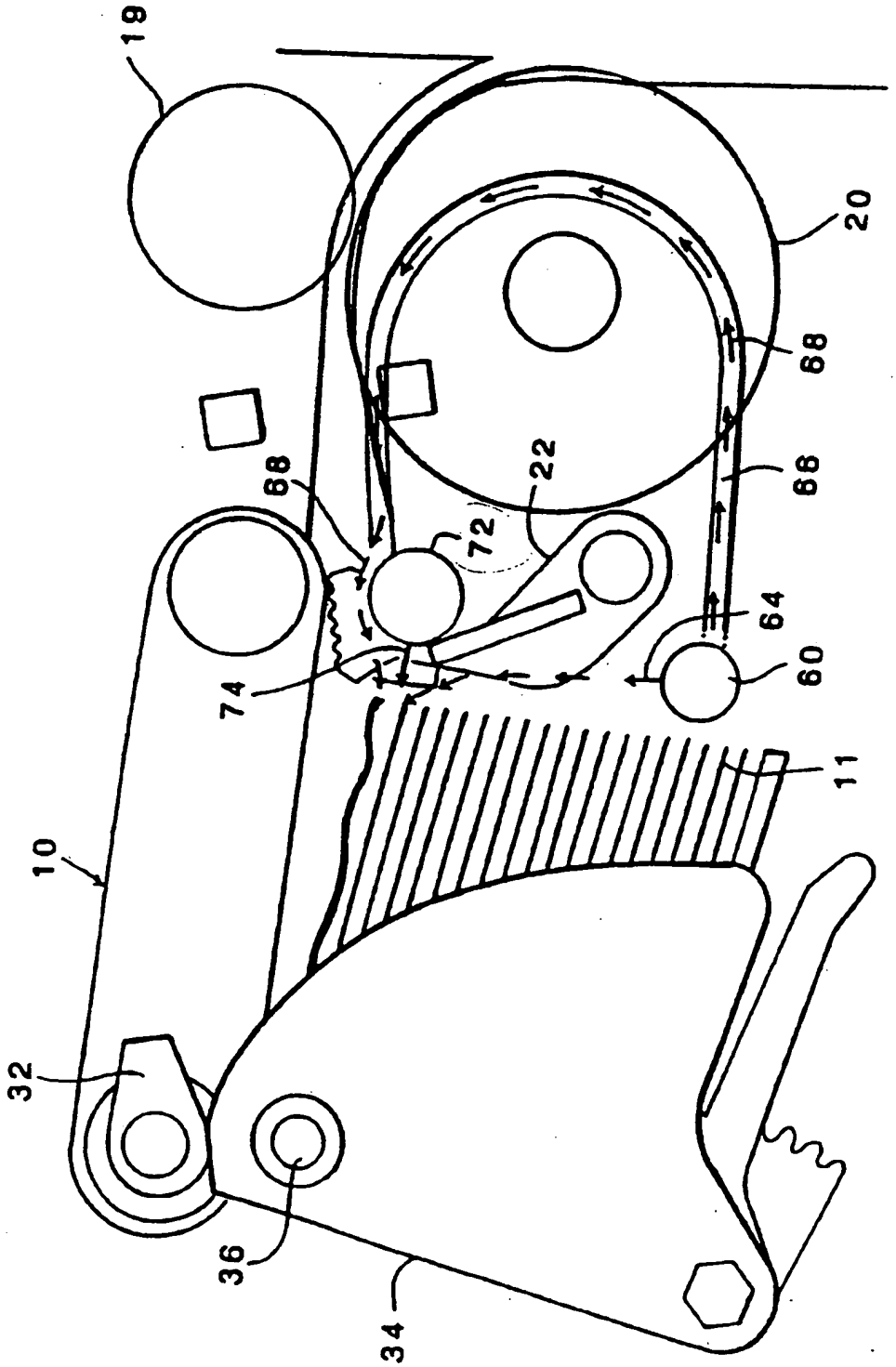


FIG.4.

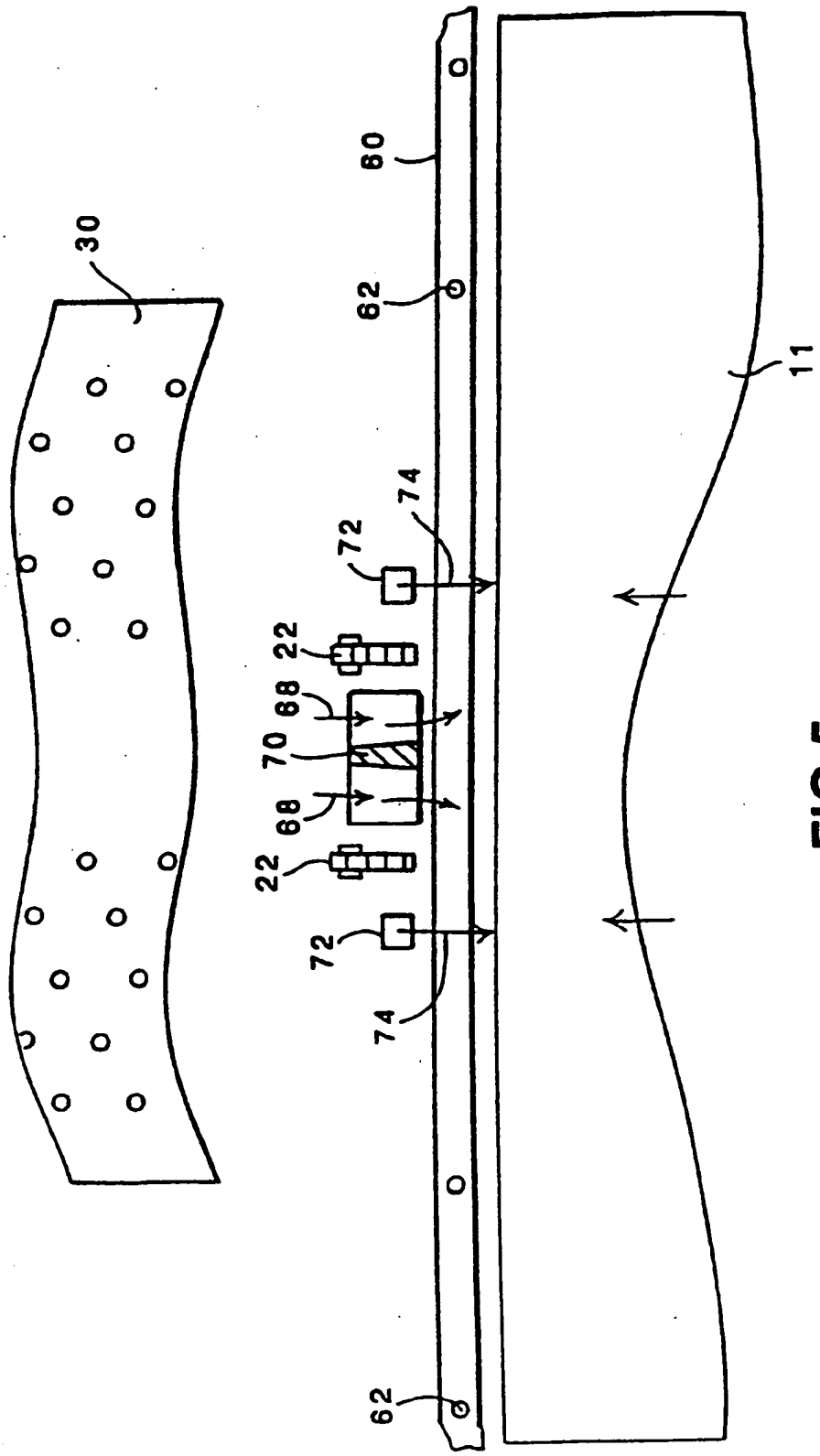


FIG.5.

APPARATUS FOR FEEDING SHEET MATERIAL

This invention relates generally to suction feeder mechanisms for the feeding of sheet material and to methods of feeding sheet material. The suction feeders of the present invention are particularly adapted for use with collating machines, but the principles of the invention have much wider application to any circumstance where one wishes to feed sheets of material, whether paper or other materials.

It is emphasised that the present invention is applicable not only to collating machines but also to photocopiers, printers, and indeed any other mechanism where sheets of material are to be moved around.

In the feeding of sheet material it is desirable that there should be no misfeeds or double feeds. It is also desirable that the mechanism should be able reliably to feed sheets of different types of material. Although there are suction feeder mechanisms which function with reasonable reliability in terms of avoiding misfeeds and double feeds, or else incorporate sensors to detect if and when such faults occur, particular problems arise if one is designing one mechanism which is intended to be able to feed sheet material of different thicknesses and compositions.

EP-B-0465062 describes a top sheet vacuum corrugation feeder with an air knife in the form of a single slot which supplies air at low pressure across the entire width of the sheet to create a thick boundary layer which causes separation of the sheets by aerodynamic drag during feeding of the top sheet.

EP-A-0619259 describes a top sheet feeder mechanism which has a corrugator in the centre of a plurality of perforated belts which move around a plenum chamber. The corrugator is an endless band which extends around the full length of the plenum chamber, and hence is not adjustable. Air is supplied to the region between the underside of the belts and the surface of the top sheet, to assist in the separation of the sheets. The bottom run of the belts and the surface of the top sheet are parallel and their separation is maintained constant by the use of a movable tray on which the sheets are stacked.

It is an object of the present invention to provide a suction feeder mechanism and a method which can reliably feed sheets of material with greatly reduced likelihood of misfeeds or double feeds.

It is a further object of the invention to provide a mechanism and a method which enables one to feed sheet material which can vary from for example thin paper up to thick sheets of plastics material which are subject to a large electrostatic charge. Sheets of plastics material are particularly difficult to feed reliably, due to the build-up of electrostatic charges, and this has created particular problems in the past. The present invention solves or at least minimises these problems.

The sheet feed of the present invention has many attributes:

a) it is very economical;

b) it does not require adjustments over a wide range of materials and sheet sizes;

c) it is rugged and reliable;

d) it operates without creasing or marking the sheets;

e) it provides a very positive feeding mechanism;

f) because of the very small amount of movement of paper and of the mechanism itself, it is possible for it to be not only very economical but also very fast.

The sheet feeder mechanism of the present invention in its broadest aspect utilises a suction device which both includes

means to impart distortion to a sheet attracted to the suction device, and also provides a novel suction effect which aids the maintenance of the sheet in the correct position and attitude for onward movement.

The novel suction device is utilised, as part of the sheet feeder mechanism, in conjunction with a multiple air flow which assists in the separation of the top sheet from a stack.

In accordance with the invention there is provided a suction device for use in the feeding of sheets of material, comprising a housing connectable to a vacuum device and having a flat surface provided with apertures through which a suction effect can be created to attract a sheet towards said surface, and means prominent from said surface to impart distortion to an attracted sheet, wherein the apertures in said surface are such that there is a boost in the suction exerted on the attracted sheet at the time that it is distorted.

Preferably, the distortion-imparting means is adjacent to the leading edge of the housing from which the sheet is fed onwards, and the surface area of said apertures is greatest in the zone to each side of said distortion-imparting means.

Preferably, the apertures in the housing surface are of chevron shape overall.

In a preferred embodiment, the apertures comprise a plurality of parallel slots, with longer slots towards the outside edges of the housing and shorter slots towards the centre.

The invention also relates to a suction head comprising one such suction device, with an endless belt on which the sheet is held encompassing the housing and arranged for intermittent advancing movement.

The invention also relates to a sheet feeding mechanism comprising such a suction head, means to support a stack of sheets adjacent to the belt, and a vacuum device connected to the housing and synchronised to operate in conjunction with advancing movements of the belt.

Preferably, the means to support the stack of sheets holds the sheets at an inclined feed angle related to an adjacent run of the belt.

In a preferred embodiment the sheet feeding mechanism includes air supply means to provide both a pulsed and a continuous flow of air towards the stack of sheets.

Preferably, a first continuous air flow is directed upwards at the leading edge of the stack, a second continuous air flow is directed towards the top sheet of the stack substantially parallel thereto, and a pulsed air flow is directed towards the leading edge of the top sheet in synchronism with the operation of the vacuum device and with the belt movements.

The advancing motion of the sheet material is synchronised with the timed application of suction preferably assisted by the external air flow which is preferably both pulsed and continuous. The timed application of suction is synchronised with an advancing movement of the belt.

The suction feeder is preferably positioned above the stack of sheets of material, with the sheets being lifted into contact with the belt for advancing movement.

Preferably, the sheets below the top sheet are positively restrained from movement towards the belt, for example by pivotable contact fingers.

Once set, the suction feeder of the present invention will function just by the timed application of suction and the driving of the belt. Adjustment of the feeder for different types of sheet material can be effected simply by adjustment of the distortion-creating means, for example by simple rotation of an eccentrically mounted wheel or roller.

In an arrangement where an endless perforated belt is movable around a pair of spaced rollers, the means to create

the distortion is preferably positioned towards that roller which is adjacent to the forward or leading end of the sheet stack. The distortion is then initiated towards the leading edge of the sheet which is being attracted from the stack.

Uniquely, the feed system requires no adjustment when changing paper sizes. One can cater for sheet sizes from 130x160 mm to 364x520 mm for example. One can use sheets from 40 to 240 gms.

In order that the invention may be more fully understood, an embodiment of sheet feeding mechanism in accordance with the invention will now be described by way of example and with reference to the accompanying drawings, in which:

FIG. 1 is a schematic side view of the feeder mechanism to illustrate the feed system;

FIG. 2 is an underneath plan view of the suction box around which the feed belt travels;

FIG. 3 is a view from below of the suction head comprising suction box and feed belt;

FIG. 4 is a schematic side view of parts of the feeder mechanism to illustrate the air flows for separation of the sheets; and,

FIG. 5 is a diagrammatic plan view to illustrate how the air flows emanate from the air vents.

In the various drawings the same parts are denoted by the respective same reference numerals.

The sheet feeding mechanism shown in the drawings comprises a suction head, indicated generally at **10**, which is designed and arranged to receive individual sheets **11** of paper, card, film or other like material from a stack **12** of sheets which are set on a supporting plate **14**. In contrast to conventional suction feeders, the sheets in the stack **12** do not lie parallel to the underside of the suction head **10** but are set at a feed angle α with the leading edges of the sheets extending downwards away from the suction head. This feed angle α is preferably within the range of 5° to 15°, preferably about 10°. The suction head **10** will be described in detail hereinafter. Each sheet **11**, as it is picked up and fed forward, is guided by guides **16, 18** to move forwards and then downwards between rollers **19, 20, 21**. In front of the sheet stack **12** are a pair of fingers **22** which are pivotable and are positioned quite close to the centre of the stack width, as can be seen in FIG. 5. These serve as stops for sheets other than the topmost sheet and each has a serrated upper surface over which the sheet being fed will pass.

The suction head **10** comprises a suction box **24** which is fitted with a front drive roller **26** and a rear idler roller **28**. Around the rollers and box runs an endless belt **30**, intermittently driven. The rear idler roller **28** is fitted with a cam **32** which is engaged by a cam **34** which is pivotable about a pivot pin **36**. By pivotal movement of cam **34** the rear edge of the suction head **10** can be raised and lowered to alter the feed angle α.

FIG. 2 shows the suction box **24** in greater detail. It consists of a rigid housing **38** which is provided with a connecting tube or pipe **40** which is connected to a vacuum device **42** (FIG. 3). The box is provided in its underside with slots, as will be described in more detail hereinafter. Around the box **24** runs the endless flexible belt **30** which has rows of perforations **44** running lengthwise of the box at regularly spaced intervals. The belt **30** is made of a material such as "Hyperlon" which is not too elastic, which has a good memory and does not generate static charges. Because the transverse width of the suction box **24** is approximately three times its length, the belt **30** is effectively a tube of material.

By the operation of the vacuum device **42** the pressure within the suction box **24** can be reduced, and by virtue of the registration of the perforations **44** with the slots a reduced pressure is created at the perforations. This means that if the suction head is positioned above the stack **12** of sheets, application of the suction will cause the top sheet to be attracted to the belt.

Positioned centrally across the width of the suction box **10** is a distortion wheel or roller **46** which is connected by a shaft **48** to an external adjusting knob **50**. The wheel or roller **46** may be eccentrically mounted on the shaft **48** so that rotation of the adjusting knob **50** will cause a change in the eccentricity of the wheel or roller **46**. The wheel **46** is preferably a grooved wheel, thus providing two circumferential ribs. The wheel or roller **46** projects from the bottom of the suction box and as it is rotated it increasingly distorts the central portion of the encompassing belt **30** adjacent to the leading edge of the box. It is to be noted that the corrugator **46** is within the belt **30**. The amount of distortion of the belt is determined by the rotational position of the wheel or roller **46** and can be set in dependence upon the nature of the materials to be advanced from the stack. Sheets which are thin or difficult to separate will need a large hump, while stiff materials which are easier to separate need less distortion.

This distortion of the central zone of the belt **30**, coupled with the suction effect created at the perforated zones of the belt means that as the top sheet in the stack **12** is lifted to the belt it has an undulation imparted to it. The distortion of the belt also contributes to the repelling of the next, underlying sheet of material in the stack, thereby helping to avoid double feeding.

In FIG. 2 the direction of movement of the sheets is indicated by arrows **52**. The pattern of slots in the suction box, which work in conjunction with the corrugator **46**, is important to the invention. As shown in FIG. 2, in each side of the box, i.e. on each side of the central corrugator, there are two outer slots **54***a*, **54***b* of equal length extending almost fully the length of the box, then a shorter slot **54***c*, and then a still shorter slot **54***d*. Slot **54***c* is about half the length of slots **54***a*, **54***b*, and slot **54***d* is about half the length of slot **54***c*. The slots all run from the leading edge of the box adjacent to the drive roller **26**. This results in a chevron pattern of slots, with the area of the suction box behind and to the sides of the corrugator **46** being flat and imperforate. This prevents creasing of thin paper. The action of the chevron slot pattern is first to grip the sheet, via the aligned perforations **44**, towards the outer edges of the suction box. Then, with actuation of the drive shaft **26**, the belt and attracted sheet advance over the surface of the suction box. The shorter slots **54***c*, **54***d* provide added suction adjacent to the leading edge of the sheet to ensure that it is held to the belt at this edge in spite of the distortion introduced by the corrugator **46**. In other words, this boost in suction is brought into effect at the time that the central portion of the sheet is distorted and might otherwise break away from the belt. The sheet is held more tightly at its leading edge when the central portion is distorted. The number, dimensions and position of the slots can be varied, provided that the leading edge boost is achieved.

In FIG. 3 the belt **30** is shown with five rows of perforations **44** on each side of the corrugator **46**. The four inner rows on each side are aligned with the slots **54***a*, **54***b*, **54***c*, **54***d* and in the passage of the belt over the suction box the perforations will pass along the length of the respective slots. The outer row **56** of perforations on each side of the belt **30** is aligned with a "dummy" slot **58** in the suction box. This dummy slot **58** can be converted into a true slot, for wider sheets of material, by breaking away a thin web of

material which initially closes the slot. If one is feeding narrow sheets then the outer slot or slots in the suction box can be masked by tape to make the suction more efficient. Although not so shown in FIG. 3, the sheet 11 in practice would be over the belt 30.

In order to achieve effective separation of the top sheet from the stack 12 it is important to use air flows. FIGS. 4 and 5 show how this is applied. FIG. 5 shows the parts in an exploded arrangement for clarity. Three different air flows are utilised. Running along the bottom of the stack 12 from side to side is an air pipe 60 which is provided with for example four holes 62 facing upwards and creating a constant upward air flow as indicated by the arrows 64 towards the margins of the sheets. From the air pipe 60 air is ducted by pipe 66 to emerge at the centre of the width of the stack in front of the topmost sheet, as indicated by arrows 68. This second, constant air flow emerges as two flows, one each side of a deflector 70 (FIG. 5), and directed one each side of the corrugator. The third air flow consists of air blasts, i.e. pulses of air, produced from two nozzles 72 positioned laterally outside the fingers 22 and directed at the leading edge of the top sheet. These air blasts are indicated by arrows 74. The combination of the air blast with the constant air flows results in excellent and reliable separation of the top sheet.

The pulsed air blasts from nozzles 72 are synchronised with the creation of the reduced pressure within the suction box. Also, the actuation of the drive for the drive shaft 26 is synchronised with the pump 42 which creates the reduced pressure, so that the advance movement of the belt, the suction effect and the pulsed air blasts are in the correct timed relationship.

Although in the embodiment illustrated in the drawings, the suction feeder is positioned above a stack of sheets, the same principle could be applied to an arrangement in which the suction feeder is positioned below a stack.

What is claimed is:

1. A suction device for use in the feeding of sheets of material, comprising a housing connectable to a vacuum device and having a flat surface provided with apertures through which a suction effect can be created to attract a sheet towards said surface and having a sheet discharge edge, an endless perforated belt on which the sheet is held encompassing the housing and arranged for intermittent advancing movement, and means prominent from said surface to impart distortion to an attracted sheet at a zone spaced from the sheet discharge edge of the housing, wherein the apertures in said surface are are of chevron shape overall such that they permit, by their surface area, the suction exerted on the attracted sheet to be greater in the direction towards the said sheet discharge edge, and to attract the sheet most strongly across its width at the zone where it is distorted.

2. A suction device according to claim 1, in which the distortion-imparting means is adjacent to the sheet discharge edge of the housing from which the sheet is fed onwards, and the surface area of said apertures is greatest along a line extending laterally across the housing to each side of said distortion-imparting means.

3. A suction device to claim 1, in which the apertures comprise a plurality of parallel slots, with longer slots towards the outside edges of the housing and shorter slots towards the center.

4. A suction device according to claim 3, in which there are four slots on each side of a central distortion-imparting means, the two outer slots on each side being of equal length, the next inner slot being approximately half the length and the innermost slot being approximately half the length again.

5. A suction device according to claim 1, in which the distortion-imparting means comprises a roller eccentrically mounted on a shaft extending across the housing, the roller being positioned centrally across the width of the housing and being rotatably adjustable due to the rotation of the shaft to vary the amount the roller projects from said flat surface.

6. A suction device according to claim 1, in which the ratio of the transverse width of the housing to its length is approximately 3 to 1.

7. A suction device according to claim 1, in which a portion of the flat surface to the rear of and to each side of the distortion-imparting means is imperforate.

8. A suction head for use in the feeding of sheets of material, comprising a suction device according to claim 1.

9. A suction head according to claim 8, in which the belt also extends over the distortion-imparting means.

10. A sheet feeding mechanism comprising a suction head as claimed in claim 8, means to support a stack of sheets adjacent to the belt, and a vacuum device connected to the housing and synchronized to operate in conjunction with advancing movements of the belt.

11. A sheet feeding mechanism according to claim 10, in which the means to support the stack of sheets holds the sheets at an inclined feed angle relative to an adjacent run of the belt.

12. A sheet feeding mechanism according to claim 11, in which the feed angle is adjustable.

13. A sheet feeding mechanism according to claim 11, in which the feed angle is between 5° and 15°.

14. A sheet feeding mechanism according to claim 10, which includes air supply means to provide both a pulsed and a continuous flow of air towards the stack of sheets.

15. A sheet feeding mechanism according to claim 14, in which a first continuous air flow is directed upwards at the leading edge of the stack, a second continuous air flow is directed towards the top sheet of the stack substantially parallel thereto, and a pulsed air flow is directed towards the leading edge of the top sheet in synchronism with the operation of the vacuum device and with the belt movements.

16. A sheet feeding mechanism according to claim 15, in which the pulsed air flow is positioned between said first and second air flows on each side of the distortion-imparting means.

17. A suction device for use in the feeding of sheets of material, comprising a housing connectable to a vacuum device and having a flat surface provided with apertures through which a suction effect can be created to attract a sheet towards said surface and having a sheet discharge edge, and endless perforated belt on which the sheet is held encompassing the housing and arranged for intermittent advancing movement, and means prominent from said surface to impart distortion to an attracted sheet at a zone spaced from the sheet discharge edge of the housing, said means comprising a roller eccentrically mounted on a shaft extending across the housing, the roller being positioned centrally across the width of the housing and being rotatably adjustable due to the rotation of the shaft to vary the amount the roller projects from said flat surface, wherein the apertures in said surface are arranged such that they permit, by their surface area, the suction exerted on the attracted sheet to be greater in the direction towards the said sheet discharge edge, and to attract the sheet most strongly across its width at the zone where it is distorted.

* * * * *

APPENDIX 6

UNITED STATES DEPARTMENT OF COMMERCE
Patent and Trademark Office
Address: COMMISSIONER OF PATENTS AND TRADEMARKS
Washington, D.C. 20231

SERIAL NUMBER	FILING DATE	FIRST NAMED APPLICANT	ATTORNEY DOCKET NO.

EXAMINER	
ART UNIT	PAPER NUMBER

DATE MAILED:

Below is a communication from the EXAMINER in charge of this application

COMMISSIONER OF PATENTS AND TRADEMARKS

ADVISORY ACTION

☒ THE PERIOD FOR RESPONSE:

a) ☒ is extended to run 4 months or continues to run _____ from the date of the final rejection

b) ☐ expires three months from the date of the final rejection or as of the mailing date of this Advisory Action, whichever is later. In no event however, will the statutory period for the response expire later than six months from the date of the final rejection.

Any extension of time must be obtained by filing a petition under 37 CFR 1.136(a), the proposed response and the appropriate fee. The date on which the response, the petition , and the fee have been filed is the date of the response and also the date for the purposes of determining the period of extension and the corresponding amount of the fee. Any extension fee pursuant to 37 CFR 1.17 will be calculated from the date of the originally set shortened statutory period for response or as set forth in b) above.

☐ Appellant's Brief is due in accordance with 37 CFR 1.192(a).

☐ Applicant's response to the final rejection, filed _____ has been considered with the following effect, but it is not deemed to place the application in condition for allowance:

1. ☐ The proposed amendments to the claim and /or specification will not be entered and the final rejection stands because:

   a. ☐ There is no convincing showing under 37 CFR 1.116(b) why the proposed amendment is necessary and was not earlier presented.

   b. ☐ They raise new issues that would require further consideration and/or search. (See Note).

   c. ☐ They raise the issue of new matter. (See Note).

   d. ☐ They are not deemed to place the application in better form for appeal by materially reducing or simplifying the issues for appeal.

   e. ☐ They present additional claims without cancelling a corresponding number of finally rejected claims.

   NOTE: _____

2. ☐ Newly proposed or amended claims _____ would be allowed if submitted in a separately filed amendment cancelling the non-allowable claims.

3. ☐ Upon the filing an appeal, the proposed amendment ☐ will be entered ☐ will not be entered and the status of the claims will be as follows:

   Claims allowed: _____
   Claims objected to: _____
   Claims rejected: _____

   However;

   ☐ Applicant's response has overcome the following rejection(s): _____

4. ☒ The affidavit, exhibit or request for reconsideration has been considered but does not overcome the rejection because _____

5. ☐ The affidavit or exhibit will not be considered because applicant has not shown good and sufficent reasons why it was not earlier presented.

☐ The proposed drawing correction ☐ has ☐ has not been approved by the examiner.

☐ Other